ADDIS ABABA ROAD TRAFFIC ACCIDENT STUDY AND POSSIBLE ENGINEERING SOLUTIONS: CASE STUDY OF AKAKI-KALITI SUB CITY ROADS

BY

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ADDIS ABABA ROAD TRAFFIC ACCIDENT STUDY AND POSSIBLE ENGINEERING SOLUTIONS: CASE STUDY OF AKAKI-KALITI SUB CITY ROADS

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This to certify that the thesis prepared by ***ATSBEHA GEBREMESKEL***, entitled: ***ADDIS ABABA ROAD TRAFFIC ACCIDENT STUDY AND POSSIBLE ENGINEERING SOLUTIONS: CASE STUDY OF AKAKI-KALITI SUB CITY ROADS*** and submitted in partial fulfillment of the requirements for the Degree of Master of Science ***in Road and Transport Engineering*** complies with the regulation of the University and meets the accepted standards with the respect to originality and quality.

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DECLARATION

This thesis is my original work, has not been presented for a degree in any other university and that all sources of material used for the thesis have been duly acknowledged.

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ADDIS ABABA ROAD TRAFFIC ACCIDENT STUDY AND POSSIBLE ENGINEERING SOLUTIONS: CASE STUDY OF AKAKI-KALITI SUB-CITY ROADS

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Abstract

This study aimed at examining the road traffic accident and possible engineering solutions: with particular focus on Akaki-Kaliti Sub-City roads. To meet the objective of the research the researcher has given attention to collect accident data, road data, and traffic data from Addis Ababa Police Commission, Akaki-Kaliti Sub-City Traffic Office, ERA (Ethiopian Roads Authority), from Addis Ababa Road and Transport Office, and field observations. Calculation and model selection of Black spot identification go with the land characteristics, objective needs, and basing other real factors required consideration the area of the study. Hence, the results of the study showed the existence of large difference in road traffic accident victims among drivers, passengers, and pedestrian in their sex and age levels. The Male drivers, passengers, and pedestrians were the most affected one as compared to their female counterparts. Moreover, the result confirmed that road traffic accident (death, serious injuries and light injuries) in the city mostly affected age categories of between 18-30 regardless of their sex, and starts declining after age 31. Consequently, the road traffic accidents were extremely affecting the economically active citizens i.e., youths and young adult groups. The road traffic accident trends in the Akaki Kaliti Sub-City roads by day of a week revealed significant growth of the severity of the accidents from 2010/11 to 2012/13 in all days of the week except in Sunday. Though it varies in hours of a day, and hence the crash has reached its maximum points when pedestrians, passengers and drivers' frequency of movement has increased, especially after 6:00 AM and reached the maximum accidents at 10:00 AM. Most of these crushes happened in Central Business District (CBD) and market land use areas with collisions like sideswipe, rear end, collision with pedestrians,broad side, and head on collusion. Most of these accidents occurred on Road junction like midblock than the Y– junction and T – junctions. Besides, the highest accident rates were associated with double carriageway in straight and level road character. Depending on these road traffic accidents and the model used areas like Saris Abo roundabout, Tirunesh Beijing Hospital (Near the Bridge), Customs Office Entrance, Total (Kaliti Shoa Bakery), Korki (Medroc) Entrance, Cheralia Biscuit Factory, and Akaki Kela (Near UNISA) were identified as Black spot areas, since they experienced the highest accident rates. Hence, recommendations of Engineering, Enforcement, Encouragement, and Education like, adequate provision of Road safety education, offering of definite land use policy, Quality drivers' training, and testing, standardized and prerequisite criteria for drives with regard to their educational background and good behavior ,traffic signals , traffic lights and their frequent technical failure should be solved, raised zebra crossing, marking zebra crossing, prohibit overtaking, constructing side walkway, widening of the pavement, streetlights, installation of marking and signs, and some areas also consider adequate median road marking, redesign and providing additional-way movement have been forwarded to alleviate the problems.

CHAPTER ONE
INTRODUCTION

1.1. Background of the problem

Road traffic accidents (RTAs) constitute major health, economic, and developmental challenges of developing countries, especially adversely affected sub Saharan African Countries (Chen, 2009). In 1999, for instance, 750,000-880,000 people died in road traffic crashes of which, about 85% of these occurred in developing countries (Downing, Jacobs, Aeron-Thomas & Sharples, 2000) and in 2002 an estimated 1.2 million people were killed in road traffic crashes (WHO, 2009; UNECA, 2009); 90% of the traffic crashes occurred in low and middle income countries of which Sub-Saharan countries had faced the highest fatality rate (28.3 per 100,000 population), which is substantially higher than any continent in the world (Peden et al, 2004).

In economic terms, road traffic accidents have negative impact on the gross national product of different countries. For instance, according to World Health Organization, the cost of road crash injuries is estimated at roughly 1% of gross national product in low-income countries, 1.5% in middle-income countries, and 2% in high-income countries (WHO, 2004). The social, economic, and political impacts of road accidents are widespread all over the world. The loss of lives, damage to property, and the sorrow it leaves in human mind are profound though the degree varies (Peden et al, 2004). Geographically, 35% to 70% of all crashes occur in urban areas and urban road networks contribute to a significant proportion of countries' national road traffic crash problem (Downing *et al*, 2000). These make traffic accident the third major killer next to HIV/AIDS and TB (Peden et al, 2004).

In Ethiopia, the situation has been worsened as the number of vehicles has increased consequently due to increased traffic flow and conflicts between vehicles and pedestrians (Guyu, 2013). Despite government efforts in the road development, road crashes remain to be one of the critical problems of the road transport sector in Ethiopia (UNECA, 2009). Every year, many

lives are lost and huge property is destroyed due to road traffic accidents in the country. The Country has experienced average annual road accidents of 8115 over the past 11 years (CSA, 2000/01-2010/11). In financial terms, Ethiopia, one of the poorest countries in the world, looses at least 400 million Birr each year due to road accidents, which was 12 million Birr per year on average, 15 years ago and was the third killing vector (Fanueal, 2006). Currently, the financial estimation of property damage (excluding human deaths and injuries), is more than 15 million Ethiopian birr annually on average (CSA, 2000/01-2010/11). According to UNECA (2009), the rate of traffic accident death in 2007/08 was 95 per 10,000 motor vehicles, which put the country on the extreme high side of the international road safety scene. Moreover, in the same year, the police report revealed that 15,086 accidents caused the loses of 2,161 lives, and over 82 million Birr, equivalent to US$7.3 million estimated cost of property damaged. (US$1 =11.34 Ethiopian Birr).Also, up to 2005/06, traffic accidents and fatalities increased at 17 % and 10 % per year respectively although there is a decreasing trend in this respect. There were 2.84 road accident fatalities per 100,000 populations in the same year (UNECA, 2009).

Consequently, the city of Addis Ababa has taken the lion's share of the road accidents. For instance, from the road crashed of 9,301 in Ethiopia during 2007/08 period, about 2,071(29%) were in Addis Ababa. According to the police reports, the total number of motor vehicle traffic accidents in Addis Ababa during the year 2000 – 2005 was about 44,000. And out of 15884 total road traffic accidents occurred in the country in 2010/11, about 7882(28%) was in Addis Ababa (CSA, 2012).

Therefore, understanding of road traffic accidents and identifying black spots has paramount importance to implement remedial solution for these severer problems. In light of these, in this research it is tried to assess and avail information on road traffic accidents and black spots of the Addis Ababa City administration, considering Akaki Kaliti Sub-city in particular.

1.2. Objectives of the study

1.2.1. General Objective

The general objective of the study is to investigate the magnitude of road traffic accidents and black spot areas in Akaki-Kaliti Sub-City of the Addis Ababa City Administration.

1.2.2. Specific Objectives

- To examine the extent of road traffic accidents in Akaki-kaliti Sub-City of the Addis Ababa City Administration.
- To identify locations with high number of road traffic accidents (black spot) areas in Akaki-Kaliti Sub-City roads.
- To explore the collision type of road traffic accidents in the identified black spots areas of the Sub-City.
- To suggest easily implementable engineering solutions (Black spot treatment) for the identified black spot areas.

1.3. Significance of the study

Previously, no significant studies were undertaken to show the magnitude of road traffic accidents and black spot areas in Akaki-Kaliti Sub-City of the Addis Ababa City Administration. Hence, the current study has the importance of

- Adding knowledge on the gap created around the issues;
- Promising in terms of resolving the problems associated with road traffic accidents;
- Offering information regarding the basic cause of road traffic accidents in the Sub-City and on the site of black spots;
- Findings of this study leading to new problems for further investigation;
- Signaling and motivating the various stakeholders to take appropriate actions by incorporating the issue in their policies and strategies; and

- Providing policy makers, researchers, institutions etc with adequate, and reliable data so as to implement feasible and appropriate engineering solutions to reduce the road traffic accidents.

1.4. Limitation of the Study

For the sake of making the research manageable, this study has been limited in scope, time, and coverage areas. Accordingly, to conduct the research on the issue of Road traffic accidents and identification of black spots in Addis Ababa City administration would be comprehensive and it needs a huge amount of money and long progress. Hence, the study has been limited to analyzing the magnitude of road traffic accidents and black spot areas in Akaki-Kaliti Sub-City of Addis Ababa city administration. Moreover, the researcher has considered very limited representative of sample respondents in interviews in order to supplement the data collected from document reviews. Besides, possible efforts were exerted to overcome the above constraints and to accomplish the desired work successfully.

1.5. Organization of the Study

The Study is comprised of five Chapters. The first chapter consists of background of the study, objectives of the Research, significance of the Study, limitation of the Study, and organization of the Study. The second chapter comprises review of related literature, review of literature mainly dealing with different citations of journal articles, books, brochures, reports, strategies, guidelines, and other similar sources employed to support this research. Chapter three is on research methodology, study design, data collection sources and type of data analysis. Chapter four consists of data analysis and data interpretations of the Study. Chapter five consists of the conclusions and recommendations and chapter six proposes future research areas.

CHAPTER TWO

LITERATURE REVIEW

2. Global accident statistics

Road accident is one of the causes for the death of people and has been ranked as one of the top leading causes of death in the world. Over millions of people are killed each year. Every day, thousands of people are killed and injured on road by traffic accident. It is the leading cause of death, disabilities and hospitalization, sever socioeconomic costs, across the world. According to (WHO),it has been estimated that RTA takes the live of nearly 1.3 million each year, As a result , nearly 3500 people die each day. In addition, the people who suffer serious injuries including disability are about 20 to 50 million worldwide.

RTAs injuries are becoming public health issues, disproportionately affecting vulnerable group of the road users, including the poor. More than half the people who die in traffic crashes are young adults whose age is between 15 to 44.

In the world, nearly half (46%) of all RTA involve pedestrians, motorcyclists and cyclists (vulnerable) road users. The economic consequences due to RTAs have been estimated between 1% to 3% of GNP (gross national product) of the world countries. In 2004, (WHO) RTAs were the 9th leading cause of death and the study forecasts that at current rates by 2030, the RTAs will rise to 2.4 million death each year and will be the third leading cause of death overtaking diabetes and HIV. Table 2:1 below shows the top leading cause of death by presenting what happened in 2004 and what will happen in 2030.

According to WHO study on (2008) Global Burden of Disease, in 2004, RTAs injures affect all age groups, but their impact is most striking among the young. The features of on people are descended. RTAs have become the second leading cause of death worldwide for age 5 to 14 year the leads cause of death for the age's 15-29 years, and the third leading cause of death among the people whose is age 30 to 44.

Table 2:1: Ten leading causes of burden of disease, world, 2004, and 2030

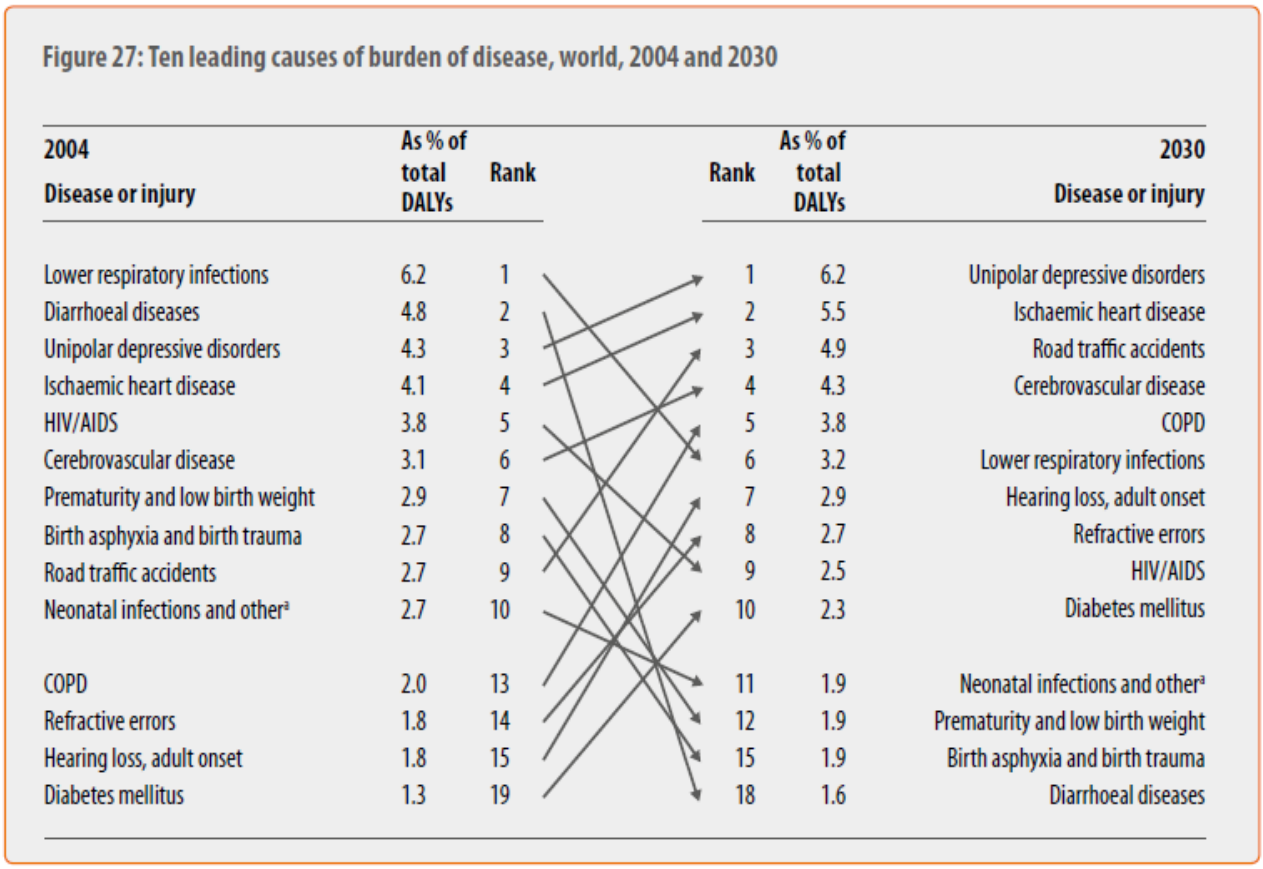


Figure 27: Ten leading causes of burden of disease, world, 2004 and 2030

2004 Disease or injury	As % of total DALYs	Rank	Rank	As % of total DALYs	2030 Disease or injury
Lower respiratory infections	6.2	1	1	6.2	Unipolar depressive disorders
Diarrhoeal diseases	4.8	2	2	5.5	Ischaemic heart disease
Unipolar depressive disorders	4.3	3	3	4.9	Road traffic accidents
Ischaemic heart disease	4.1	4	4	4.3	Cerebrovascular disease
HIV/AIDS	3.8	5	5	3.8	COPD
Cerebrovascular disease	3.1	6	6	3.2	Lower respiratory infections
Prematurity and low birth weight	2.9	7	7	2.9	Hearing loss, adult onset
Birth asphyxia and birth trauma	2.7	8	8	2.7	Refractive errors
Road traffic accidents	2.7	9	9	2.5	HIV/AIDS
Neonatal infections and other[a]	2.7	10	10	2.3	Diabetes mellitus
COPD	2.0	13	11	1.9	Neonatal infections and other[a]
Refractive errors	1.8	14	12	1.9	Prematurity and low birth weight
Hearing loss, adult onset	1.8	15	15	1.9	Birth asphyxia and birth trauma
Diabetes mellitus	1.3	19	18	1.6	Diarrhoeal diseases

Source: Study Global Burden of Disease undertaken by the World Health Organization (WHO)

Using a 30-day definition modeled data for the 178 countries including Ethiopia, almost all death sources show that about ¼ of RTAs death are among men and the highest impact is on the economically active age ranges. Men, women, or children walking, biking, or riding to work, school, playing in streets or setting out long trips are never having guarantee to reach destinations or to return home safely (WHO). Each year, thousands of people have spent many weeks in hospital, often facing severe crashes with many of them unable to live, work or play as they used to do. For instance, according to 2010, it is estimated that 1.24 million people lost their live as a result of RTAs (WHO). Although RTAs are the major global public health problem worldwide with 90% of deaths and morbidities occurring in low- and middle-income countries As a result of urbanization and increasing vehicle ownership in developing countries RTA Problem in low and middle income countries is the highest, and 90 percent of road traffic deaths

occur in low and middle income countries which claim less than half (48%) of the worlds registered vehicle fleet. Fatality rate for low-income country is 21.5 per 100,000 population, and it is 19.5 per 100,000 population in middle-income countries, but high-income countries register the least fatality rate which is 10.3 per 100, 000 population (see Table 2:2)

Table 2:2: Fatality rates per100,000 population (2004)

WHO REGION	HIGH-INCOME	MIDDLE-INCOME	LOW-INCOME	TOTAL
AFRICAN REGION[b]	—	32.2	32.3	32.2
REGION OF THE AMERICAS[c]	13.4	17.3	—	15.8
SOUTH-EAST ASIA REGION[b]	—	16.7	16.5	16.6
EASTERN MEDITERRANEAN REGION	28.5	35.8	27.5	32.2
EUROPEAN REGION	7.9	19.3	12.2	13.4
WESTERN PACIFIC REGION	7.2	16.9	15.6	15.6
GLOBAL	**10.3**	**19.5**	**21.5**	**18.8**

[a] 30-day definition.
[b] No high-income countries.
[c] No low-income countries.

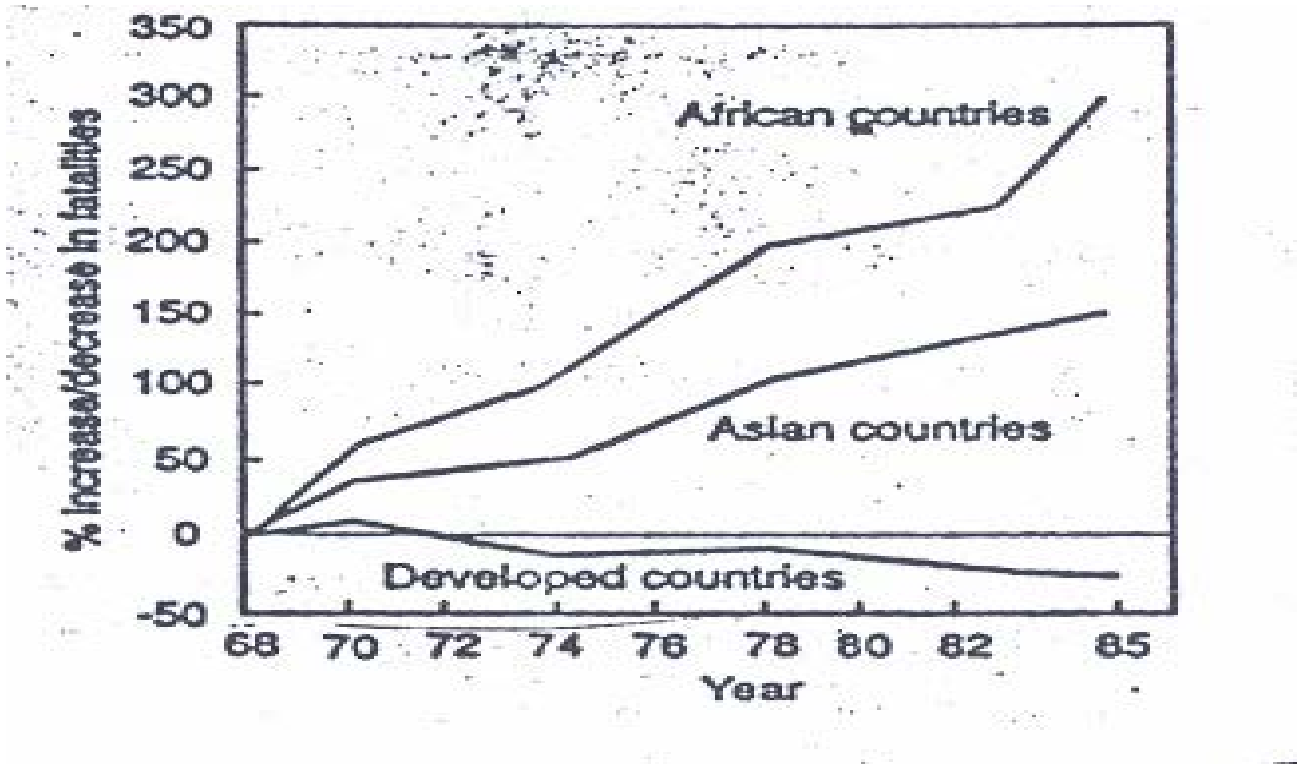
In 2005, World Health Organization (WHO) reported that traffic accidents had taken the second leading cause of death for the people whose age is 5 to 14 next to lower respiratory, the first cause for death of people whose age is 15 to 19, and the third leading cause of death for the people whose age is between 30 to 40 next to HIV/AIDS and Tuberculosis. World health organization reported that in 2000, l.26 million deaths occurred worldwide (20.8 per 100000 people). Out of this, 90% of the death is occurred in low and middle-income countries with south East Asia and Africa having the highest rates. In 2010, from the esteemed 1.24 million lives were lost as the result of RTAs, of which 80 % was in middle-income countries where 27 % of the world's population lives, but where only half of the world-registered vehicles are owned and driven. The African region has the highest road traffic fatality rate (32.2 per 100,000) while the European region has the lowest fatality rate (32.2 per 100,000) (WHO, 2012).

Table 2.3: Estimated global road traffic injury related deaths

Estimated global road traffic injury-related deaths			
	Number	Rate per 100 000 population	Proportion of total (%)
Low-income and middle-income countries	1 065 988	20.2	90
High-income countries	117 504	12.6	10
Total	1 183 492	19.0	100

Source: WHO Global Burden of Disease project, 2002, Version 1

According to the detailed analyses of global accident statistic by the UK transport research laboratory (TRL), the change in road accident fatalities in the low and middle-income countries from 1965-85 was found increasing highly. The graph given below shows those African countries had the highest rate as compared to the others between 1968 and 1985. The number of deaths increased by over 300% in African countries and 170% in Asian. It is about 20 to 30 times as high when compared with the high-income countries. However, the accident fatalities in the developed countries have been decreasing yearly.



Source: TRL, (2000)

Figure 1: Percentage change in road accident fatalities in Asia, Africa and developed countries 1968-85

From the low-income countries, Ethiopia has been found one of the countries with the highest rate of fatalities per vehicle of accident in the world .According to the Ethiopian Government reports, at least 70 people die in every 10,000 vehicle- accidents per year.

2.1 The factor that cause traffic accident

The causes of traffic accidents are: road, the driver, the road user, vehicle, and environmental factors. According to Ruman,K.(1985), studies from the American and British reports; accidents occurred 57% due to driver factor, 27% due to combined roadway and driver factor, 6% combined vehicles and deriver factor ,3% a combination of the road, drivers, vehicles ,2% vehicle factor ,1% combined of vehicle and road user factor. Road network in Africa is expanding fast, and similarly maintenance standards are improved resulting the safe standard of the road. However, in Ethiopia, due to lack of trainings on the subject area, contribution of roads and environment to traffic accidents are underestimated.

2.1.1. Vehicles

The main cause for the traffic accident are due to vehicles' malfunction of the braking system ,body, tyre, improper inspection and maintenance. According to the TRL conducted from 1968 to 1969, on the spot investigation of 274 accidents, vehicle defects were found to have contributed to 18% of the accidents. University for the United States Department of Transportation in 1973, Vehicle defects were the contributor to 5% of defect related accidents and contributed to 13% of defect-related accidents when considered in correlation with either the human factor or the environment. Moreover, braking systems were identified as the major cause followed by tyres and wheels.

2.1.2. Drivers

The driver's characteristics are important variables to be considered in the analysis of traffic accidents. Since drivers have a major role in many accidents, the driver is the key factor in most of the accidents and this is due to driver's judgment, skill and emotional makeup, age, sex, marital status, training, use of alcohol and drug, fatigue, use of crash helmets and safety belts, and speed. The Traffic Injury Research Foundation of Canada (1991; in NHTSA, 1995) reported findings of attempts to separate the effects of age and experience-related factors in traffic crashes. Crash rates were observed to decrease with increasing driving experience, among drivers of the same age. With respect to gender findings, it showed that younger male drivers, who commit more violations, are more likely to behave in a risk-taking manner, displayed through faster and more deviant driving styles and they have also been observed to be more likely to be involved in a traffic accidents.

2.1.3. Roads

The characteristics of a road have a great influence on traffic accidents. Improper standards of road construction and maintenance hare a relationship with accident. The road can bring immeasurable change in the accident (using properly designed standard construction of the road with the correct specification, vertical alignment, sight distance, supper elevation, carriageway width, width condition, shoulder, road signs, and road markings, junctions' designs, pavement surfaces, narrow bridges and culverts, median, width, and street lighting.

2.1.3.1.Horizontal alignments

2.1.3.1.1. Curve radius

Most of the past Studies show that accidents often occur at curves. Ding jianmei & Pei yulong (2000) reviews from the study of Shenda Freeway that accident rate and curve radius have a close relationship. This means, accident rate reduces as the radius of the road increases; and the curves with the same or similar radius are safer than with different radius. A small radius, which is inserted into long and straight line, is dangerous, and the study conclude that modification of horizontal alignment is one of the effective countermeasures for highway accidents.

All being equal, crashes are more likely to occur on highway curves than on tangents (straight sections of road). Glennon (1987) quotes results which suggest that the average crash rate for curved road segments is three times that of tangents, and the average single vehicle's, run off road crash rate is four times higher. Moreover, curved road segments have higher proportions of severe wet road and icy road crashes.

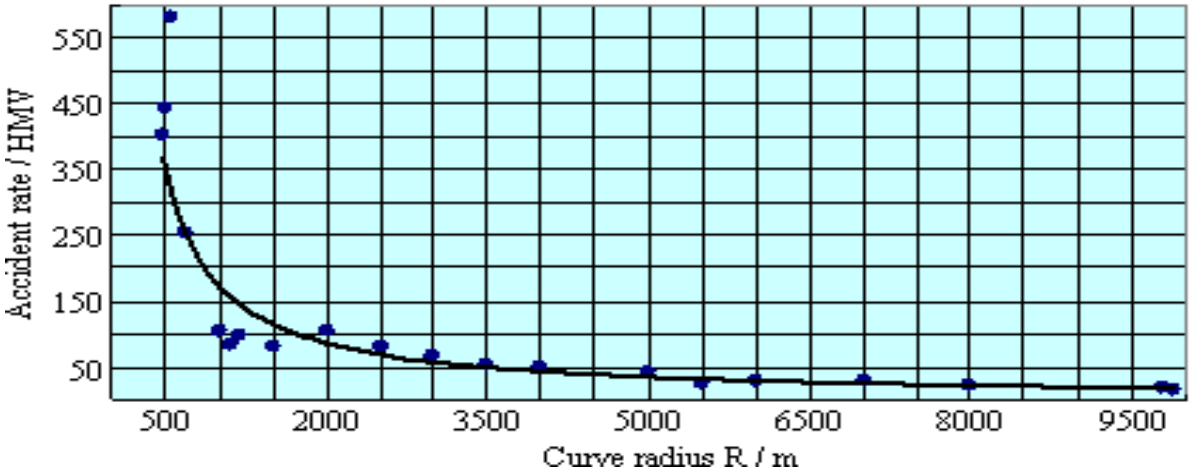


Figure 2: Relationship of AR and radius on Shenda Freeway in China

Getu (2007) reviewed that generally sharp curves result high accident rate than more gentle curves, especially below 20 m radius rate of accident is increasing. Almost, all previous studies' conclusions indicate that rate of accident is high on horizontal curves, at intersection and bridges. Brinkman, C.P (1984) claimed that the average rate of accidents on highway curve is three times that of average rate of accident for highway tangent and as the radius of horizon curve decreases, the rate of the accidents increases.

Garben & Hoel (2009) showed that the accident rate for horizontal curves is 1.5 to 4 times greater than straight section. Sarbaz Othman & Robert Thomson (2009) studied the effect of the curvature on the accident rate and summarized that accident rate decreases with increasing radius of curves, for both right and left curves. Left turn curves have higher accident rate than right turn Curves. Road sections with left curve and radius less than 100 meter have two times accident rate as compared to right curve radius less than 100 meter. In addition, road section with left curve radius of less than 100 m has accident rates that are four times as high as those on section with curve radius greater than 500 m. According to the Iyinam, A.F., Iyinam, S. & Ergun, M. (2000) review horizontal curves as radius of curve decreases, the accident rate on the curves increases. Figure 3 shows dependence of relative accident rate on curvature change rate and radius of curve.

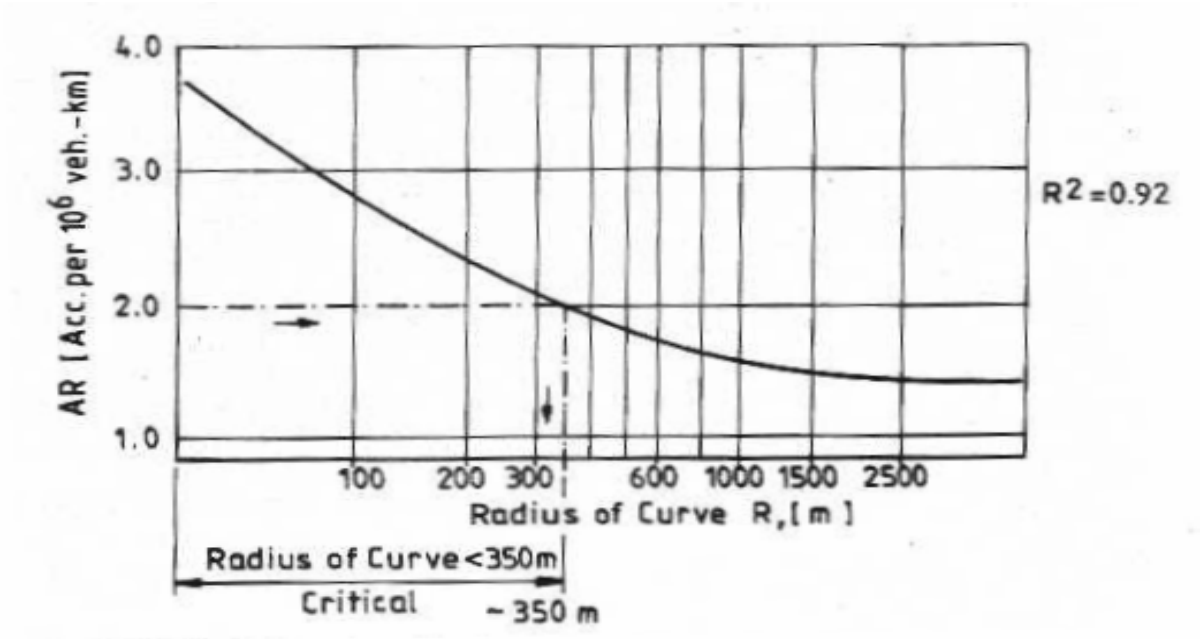


Figure **3**: Dependence of relative accident rate on curvature change rate and radius of curve

2.1.3.1.2. Deflection angle

According to studies by Ding jianmei & Pei Yulong of at Shenda, freeway small angle or deflection leads to steep curves to drive and unfavorable to traffic safety. Figure 4 shows accident rate vs. deflection degree.

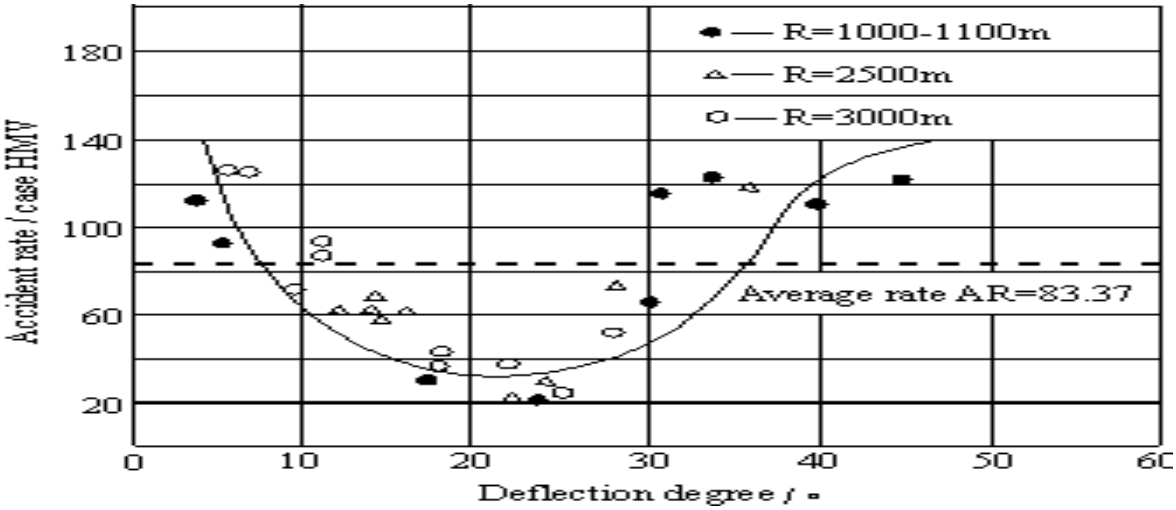


Figure 4: **Accident rate vs. deflection degree**

According to the above graph, when angle of deflection varies from 0^o to 45^o, accident rate decreases with angle of deflection increasing to minimum level 7^o, and then less or equal to 7^o of deflection angle increases rate of accident with increasing of deflection angle. Getu (2007) reviews that section with curvature of 5 to 10 degrees is twice higher than a section with degree of deflection 1 to 5.

2.1.3.2. Vertical alignments

2.1.3.2.1. Grade

Steeper grades are generally associated with higher crash rates. For example, Roy Jorgensen (1978) suggested that both crash rate and severity increase with gradient, and both upgrade and downgrade. Organization for Economic Cooperation and Development (1976), Hillier, and Wardrop (1966) reached a similar conclusion, but suggested that downgrades were the greater problem. Hoban (1988) concluded that steep grades above about 6 per cent are associated with a higher crash rate.

Chrisro J.Bener & Joster Maki (1999) review steeper grades increase the accident rates, and the accident rate in mountainous terrain is higher than in flat terrain. They summarize that the effects of vertical road alignment on accident are excessive speed, differential speed between vehicles and visibility difficulty for diver on crust curve.

Iyinam, A.F., Iyinam, S. & Ergun, M. (2000) studied that the accident rate is highly increasing with increasing of road grades at the point of high slope section. For the low radius horizontal curves, the accident number is high. The effect of grade type on the accident rate is determined at a highway of 72 km in America Flzer Mountain from 1960 to 1996. The study clearly illustrated this as shown in Figure **5** below.

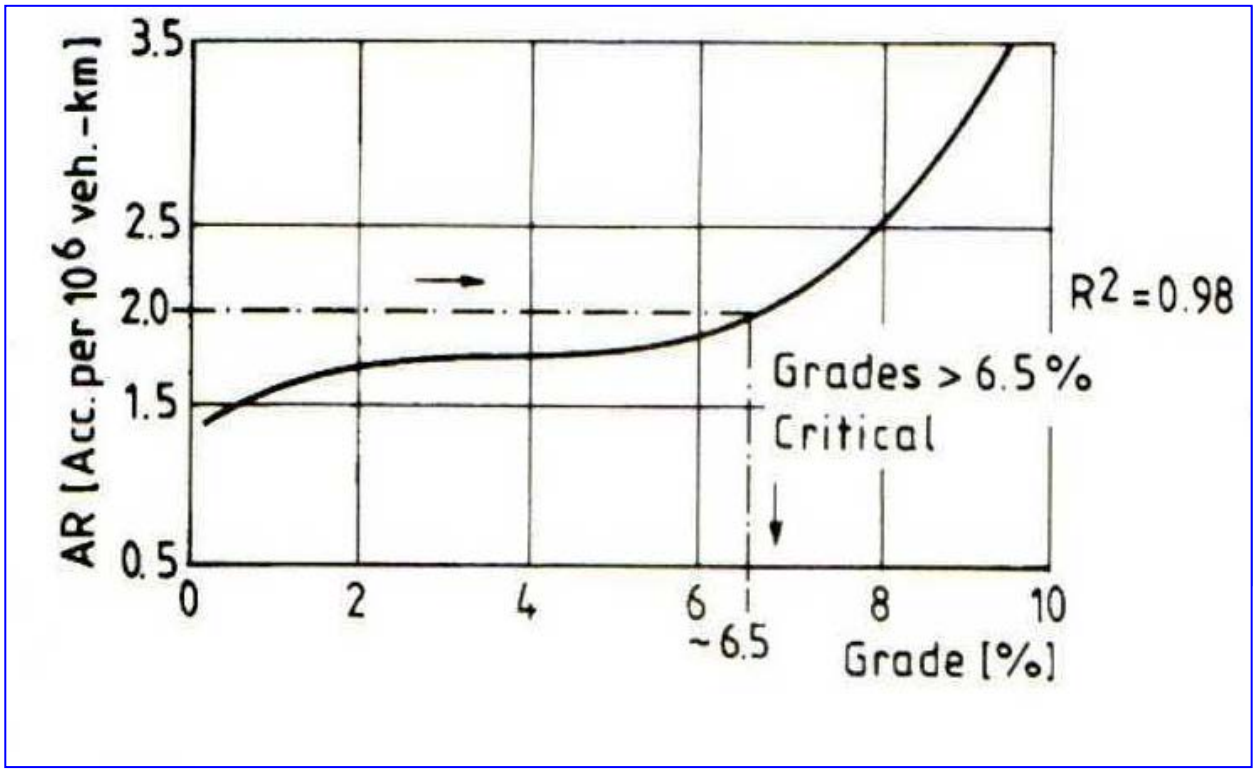


Figure 5: Dependence of relative accident rate on grade

Emergency braking distance downgrade is longer than that of braking distance upgrade. Due to this, more accident occurs at downgrade than upgrade.Figure 6 shown accidents at downgrad and upgraden

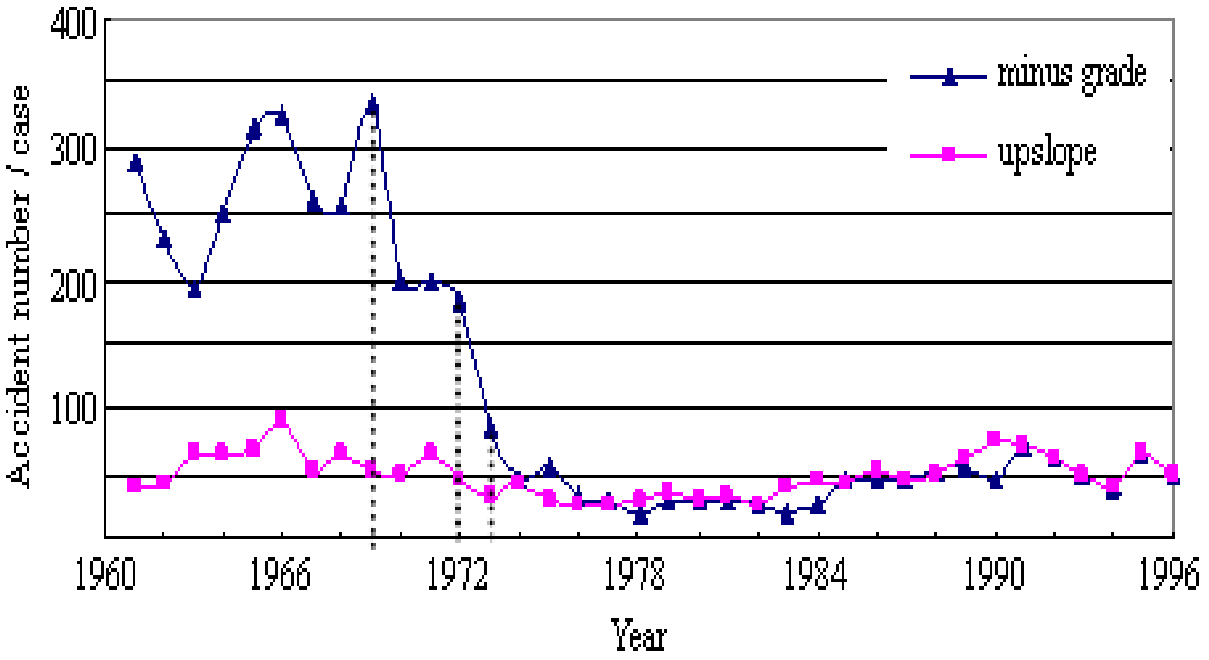


Figure 6: Accidents at minus grade and upslope

Based on the above graph before safety measures was taken for the highway, accident rate was high on both upgrade and downgrades but significantly higher accident rate on downgrade than upgrade. After 1969, by increasing two directional lanes, remedial measures were taken to upgrade, and downgrade, and accidents are decreasing. Again, after installing a speed limit signs, the accidents get decreased and keep stable in absolve relatively. Sarbaz Othman & Robert Thomson (2009) studied the effects of grades on accident rates and reported that accident rate on downgrade is slightly higher than on upgrades, and upgrades have less effect on accident rate while accidents' rate increases with increasing downgrade.

2.1.3.3. Cross section elements

Cross-section elements are one of the main important elements that will be considered in designing properly in order to decrease road accident. These include: lane width, shoulder width type, and cross section type.

Sarbaz Othman & Robert Thomson (2009) studied the influence of carriageway width on the accident rate and suggested that the accident rate decreases with increasing lane width greater than 5.8 m, and the carriageway width of 5.8 m has the lowest accident rate on one lane roads.According to Ding Jianmei & Pei Yalong studies (2009) ,from the acceptant data of 76 streets in Harbin, accident rate of a cross section element with different type is obtained as shown in Table **2.4** and Table **2.5**

Table 2.4: Safety Influence Factor of Cross Section (TSIFCST) of urban streets

Type of cross section	Accidents	AR (A/HMV)	Sample streets	Average AR (A/HMV)	SIFCST
Without any strip	1191	10011	61	164	1.26
With median strip	111	520	4	130	1.00
With separation strip	273	1341	10	134	1.03
With both median strip and separation strip	220	415	4	104	0.80

Table 2.5: Safety Influence Factor of Lanes Number (SIFLN) of urban streets

Number of lanes	Type of lanes	No of Accidents	AR (A/HMV)	Sample streets	Average AR (A/HMV)	AR of different lanes number (A/HMV)	SIFLN
Double lanes	Double lanes	169	1584	18	88	88	`
Four lanes	Four lanes	511	2075	25	83	86	1.00
	Four lanes with median strip	4	150	2	75		
	Four lanes with separation strip	59	404	4	101		
Six lanes	Six lanes	357	1078	11	98	83	0.97
	Six lanes with median strip	20	76	1	76		
	Six lanes with separation strip	214	450	6	75		
Eight lanes	Eight lanes	109	273	3	91	81	0.91
	Eight lanes with median strip	75	162	2	81		
	Eight lanes with separation strip	220	284	4	71		

2.1.3.3.1. Lane Widths

A study that was conducted by DeLuca (1985) in Miami-Dade, showed a significant increase in sideswipe crashes with the decrease in lane width. Another study conducted by Zegeer et al. (1981) found that wide lanes had accident rates 10 to 39% lower than those on narrow lanes. The study showed that heavy vehicles overtaking other heavy vehicles remain centered in their lanes only when lanes were 12 feet (3.6 m) wide or wider. Studying the effects of lane width on trucks, Joshua and Garber (1990) found that lane width has the greatest effect on the probability of a truck accident, and that the probability for a truck accident increases as lane width decreases.

On the other hand, the study conducted by Hauer (2000) attempted to show the link between lane width and safety. Accordingly, the first link is that the wider the lane, the larger will be the average separation between vehicles moving in adjacent lanes. This may provide a wider buffer to absorb the small random deviations of vehicles from their intended path .The second link between safety and lane width is that a wider lane may provide more room for correction in near-accident circumstances.

National Association of Australian State Road Authorities (1988) quotes an Australian study where the sealed width on rural highways were widened from 4.9 to 5.5 m, and from 6.7 to 7.3 m, with a casualty crash reduction of 43 per cent. Transportation Research Board (1987) quote an American study where 2.7 m lanes on rural roads were widened to 3.3 m ,and 3 m lanes were widened to 3.6 m , with a serious injury crash rate reduction of 22 %.

According to Iyinam, A.F., Iyinam, S. & Ergun, M. (2000) studies as the pavement lane width increases, accident rates decrease and is illustrated in figure **7** below.

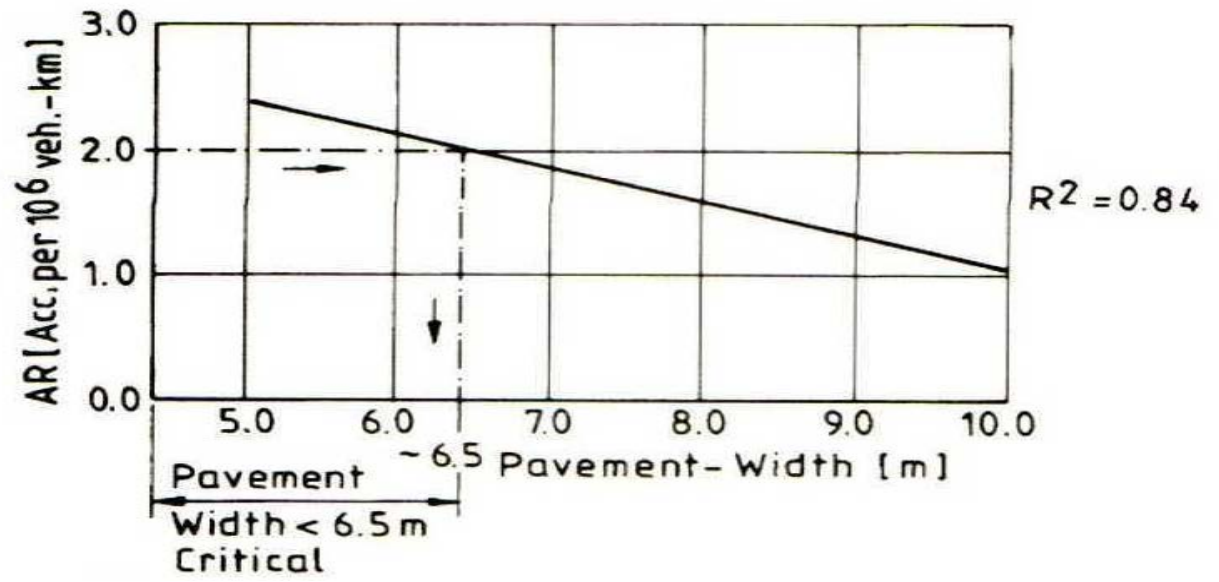


Figure 7: Dependence of relative accident rate on carriageway width

2.1.3.3.2. Shoulders

Shoulders are needed for parking, stopping vehicles, and overtaking crossing vehicles. The width of shoulder on crashes is less conclusive. However, there is some evidence that crash rates reduce as shoulder width increases up to 3m. For example, an American study (Zegeer, Deen and Mayes, 1981) produced results which showed a 21 % reduction in crashes when a road with no shoulders over the shoulders had of 0.9-2.7 m in width provided.

The Chrisro J.Bener & Joster Maki A.(1999) making reviews study showed that shoulders wider than 2.1m have significance lower accident rate than those narrower than 2.1m, and according to other studies, roads without shoulder exhibit relative low accident rates, which are a one-lane earth roads where speed is very low.

Iyinam, A.F., Iyinam,S.& Ergun,M.(2000) studies tested the relationship between accident rate and shoulder width and showed that ,as the width of a shoulder is increased, the number of accident is decreased .With respect to type of shoulder the Chrisro J.Bener & Joster maki (1999) reviewed from various studies that accident rates become high on roads with a wider lane and paved shoulder than on wide lane with a gravel shoulder with 2 to 2.1m wide.

2.1.3.3.3. Medians

The separation of opposing streams by a median leads to significant crash reductions. In urban areas, medians should ideally be wide enough to protect turning or crossing vehicles. National Association of Australian State Road Authorities (1988) reports aVictorian study where 42 km of 2-lane highway was replaced with a 4-lane divided highway, with a 30 % crash reduction. It also reported an Adelaide study, which compared crash rates for 4-lane roads having wide medians, narrow medians, and painted narrow medians with 4-lane roads without medians. Compared with the undivided roads, the others reduced the crash rate by 30% in narrow painted median, 48% in narrow raised median, and 54% in wide median.

2.1.3.4. Sight distance

Sight distance is a distance along the road surface at which a driver has visibility of objects stationary or moving at a specified height above the carriageway. Getu (2007) reviews from studies in Sweden and concluded that increasing of sight distance results in decreasing of accident rate. Sight distance is particularly important for trucks since their poorer braking performance must be in part compensated by greater sight distance (Jarvis, 1994).

Neuman and Glennon (1983), in a study of stopping sight distance found that different geometric conditions were associated with hazards. These were divided into three groups as follows:

- Minor hazards: tangent horizontal alignment, mild horizontal curvature (>600 m radius), mild downgrade (< 3 per cent);
- Significant hazards: low-volume intersections, intermediate horizontal curvature (300-600 m radius), moderate downgrade (3-5 per cent), structures;
- Major hazards: high volume intersections, Y-intersections, sharp curvature (< 300 m radius), steep downgrade (> 5 per cent), narrow bridge, narrowed pavement, freeway lane drop, exit or entrance downstream along freeway.

2.2. Black spot treatment

In most developed countries, by taking simple countermeasures, accidents are reduced to 40 to 50 % and in some areas to 80 %. Human error is the major causal factor in road accidents. However, engineering measures and planning improvements, such as, traffic signals, pedestrians' crossings, junction layouts, and speed control humps can affect road user behavior in such a way that errors are less likely to happen, or when they do happen, the environment can make them less serious (TRL). Some of the common types of remedial measures are stated in Table 2.6.

Table 2.6: Accident situation and potential remedial

General accident type	**Potential Remedial**
Skidding	Restoring surface texture
Collision with roadsides obstruction	- Better delineation - Guardrails - Safety fences - guide posts
Pedestrian /vehicle conflicts	- Pedestrian /vehicle segregation - Facilities for pedestrians - Pedestrian protection
Loss of control	- Road marking - Delineation - Speed control - Guardrails
Darkness	- Reflection signs - Delineation - Road markings - Street light
Poor visibility	- Conspicuity - Realignment - Improved sightlines
Poor driving behavior	- Road markings - Enforcement - Media barriers

General accident type	**Potential remedy**
Intersection	
Turning Movement	- Channelization - Signals - Turn prohibitions - Round about
Overtaking	- Channelization - Markings
Pedestrian /vehicle conflict	- Refuges - Crossing facilities - Underpass/ over bridges - Guardrails /fences
Poor visibility due to parking	- Parking controls
Darkness	- Lighting - Reflecting signing /marking
Links	
Parked vehicles	- Parking controls - parking provision
Speeding	- Speed limits - Enforcement - Speed control devices
Pedestrians	- Access control / road closures - Crossing facilities - Guardrail / fences - Wider foot ways - Underpass / over bridge

CHAPTER THREE

METHODOLOGY OF THE STUDY

3.1. Study Design

The main purpose of the study was to identify location with high number of road traffic accidents and to identify the causes of the accidents on that black spot and then suggest engineering remedial measures for the identified black spot areas. The study design included both quantitative and qualitative type. Since in situations where two strategies might be considered attractive, it is possible to use multiple strategies in a given study. Therefore, descriptive with document analysis was applied.

3.2. Target population and area

The target area and population for the study were Akaki-Kaliti Sub-City major roads,vehicles, drivers, road users, and environmental conditions.

3.3. Data sources

Primary and secondary data sources were the best sources for the study such as basic field survey was considered to collect the actual traffic flow, traffic composition and road characteristics on the actual field observations. Whereas, the secondary data were collected from Addis Ababa police commission, Akaki-kaliti Sub-City traffic office, ERA, and also from the city government of Addis Ababa road and transport bureau.

3.4. Data collection

For the purpose of analyzing of safety problems and suggesting countermeasures, information is needed on crashes or accidents, and it is desired to relate crashes to exposure. Some measure of traffic volumes is also necessary; therefore, the necessary reliable data that were collected are accident data, road data, traffic data, and field observations.

3.4.1. Road accident data

To enable systematic analysis of the road crash problem at any location, the following information about each crash is required (Howie, 1989)

Where crashes occur: location by map co-ordinates, road name, road classification, and road Layout and type of traffic control;

When crashes occur: by year, month, day of month, day of week and time of day;

Who was involved: people, vehicles, animals, and roadside objects;

What was the result of the crash: fatal, personal injury, or property damage; and

What were the environmental conditions: light condition, weather and pavement surface condition; and **how (or why)** did the crash occur.

Therefore, road accident data wear collected from Addis Ababa Police Commission booklet compiled by traffic police officers during 2008/9-2012/13 and from Akaki-Kaliti policy stations data that were recorded during 2010/11-2012/13. From these, the collected data include;

- Location, name and classification of the road & intersection;
- Location type of the area that is nearest for college, factory, religious, recreation, office complex, hospital, residential, open area, bus stop, petrol pump, pedestrian crossing, narrow bridge culvert, and others;
- Date, month, years, day of the week, time, Holiday.
- Light conditions(day light, dark hour with good, street, dark hour with poor street light, dark hour with no street light);
- Weather condition (fine, mist/fog, cloudy, light rain, heavy rain, hot, cold wind, other);
- Classification of the accident (fatal, serious injury, light injury, property damage only);
- Type of the vehicle and manufacture years;
- Involvement (pedestrian, animal and other objects);
- Nature of the accident(over turning, head-on collision, rear-end collision);
- Name, sex, age, education, address of the driver, type and license number.
- Vehicle involved (load, vehicle defect / brake, steering tyres and other);and
- Other than drivers involved in accidents (age, status).

3.4.2. Road data

The road data collected from Addis Ababa Road Authority, ERA, and field observation includes;

- Road way (number of lanes, lane width, surface condition);
- Vertical Alignment (grade on tangent (%) , grade on curve (%),sight distance (m));
- Horizontal Allayment (degree on curve (degree);
- Shoulder (width (m), surface condition (good / bad));and
- Traffic control (Delineator, Guide sign, Lighting , Marking)
- Median (media width (m)).

3.4.3. Traffic data

To enable the estimation of exposure, information on traffic flow is required. Two-way annual average daily traffic (AADT) is normally the best that can be obtained (Sanderson, Cameron, and Fildes, 1985) unless hourly flows are available from either special collections or can be extracted from traffic signal detector inputs. Sanderson, Cameron, and Fildes (1985) note that if AADT volumes are unavailable, estimates will often suffice since the calculation of exposure is not sensitive to minor estimation errors. Similarly, if count data are not available for every year, interpolation between years is acceptable. Thus, fieldwork was undertaken to count for the traffic flow and traffic composition in addition was collected past traffic data on AADT from AACRA, Addis Ababa Municipal, and ERA.

3.5. Methods of data processing and analysis

After collecting the necessary information, data processing and interpretations were done using Statistical Package for Social Sciences (SPSS) version 20.0 and descriptive methods in the form of table, charts, and graph. P-value below 0.05 (95% confidence interval) was considered as statistically significant and was undertaken to suggest possible engineering measures and to identify section length and traffic volume influence on the accident.

For the identification of black spots, there is a wide range of methodologies available ranging from simple models based on actual accident count to advanced statistical models based to estimates. The common methods used to identify black spots are:

- Accident frequency method (Layton, 1996; McMillen, 1999). This Method uses the number of accidents at a location to identify its safety performance. Locations with more than a predetermined number of accidents are classified as high-accident locations. But, the shortcoming is, the difference of road and traffic conditions were not taken into account.
- Accident density method (Ogden, 1996; SEMCOG, 1997; Traffic Institute, 1999; NCHRP, 2000) .The accident density is calculated from the number of accidents per unit length for a section of highway. Sections with more than a predetermined number of accidents are classified as high accident locations.
- Accident rate method (Layton, 1996; McMillen, 1999). This method uses accident numbers divided by vehicle number to provide rates such as accidents per million entering vehicles per spot location and accidents per million vehicle-Km for sections of highways. Locations with higher than a predetermined rate are classified as high accident locations. But,the shortcoming is that accident rate value is high in the section where traffic number value and accident number value are low .Another shortcoming is that accident rate value is low in the section where traffic number value and accident number value are high.
- Accident severity method (McMillen, 1999, Layton, 1996).The concept of this method is that the number of fatal and/or injury accidents at a location or section of highway are given a greater weight than property damage- only accidents.
- Quality control methods (Homburger, 1996; Layton, 1996; Traffic Institute, 2000) .This is the method that is used for section of black spot segments and spots in Aaki-Kaliti Sub-city roads. The logic of this method is that a location is considered to be a black spot if its safety parameter shows higher values than the critical value. They assured control of the quality of the analysis by applying a statistical test. This is based on the assumption that occurrences of traffic accident follow the Poisson distribution. Several parameters can be used such as accident rate, accident frequency, and accident severity. For example, when using accident rate as a parameter, the locations with an accident rate that is greater or significantly greater than the average accident rate for the similar region are pointed out. In other words, the locations with accident rate greater than the critical rate are classified as a black spot location.

- All the above common methods of black spot identification are used by many transport research centers; however, the availability of input data decides the method to be employed for identification of black spots. For instance, for the above listed methods of black spot identifications, their data requirements are shown in table **3.7** below.

Table 3.7: Data Input Requirement for Different Black Spot Identification Methods

Data Input	Accident frequency method	Accident density method	Accident rate method	Accident severity method	Quality control methods
Accident summaries	X	X	X	X	X
Traffic volume data			X		X
Road data		X	X		X
Accident severity				X	
Average accident experience	X	X	X	X	X
Statistical constants					X

- The time interval used in processing of black spot identification is neither long or nor shorter time since if longtime data is used, traffic conditions can cause changes in the pattern of accidents, and if it is short time, it will enable early action to be taken at sites at which sudden increases in accident numbers or accident severity have occurred. Therefore, it is often considered that three years is a reasonable period for analysis. May (1964) used accident data which were collected over a 13-year period, but he concluded that the optimal time interval should be three years, and that there is no significant gain in reliability beyond a three-year period. That is why the data that were used for identification of the black spot sections in the sub city of the Akaki-Kaliti roads are the recent three years (2010/11-2012/13). Using the quality control method (Zegeer: 1982) of accident rate calculation, critical accident rate was undertaken by using the following analysis method. The result provides the data for ‘Accident Rate’ from Equation (1) used for determining ‘Average

Accident Rate' (Ra) and calculating critical accident rate (Rc) as shown in Equation (2). It is based on the assumptions that the crashes are approximated by the Poisson Distribution.

- Accident Rate

Uf = U x 106 / (AADT x 365 x n x L).....1

- For Junctions(or for accident spot):

Uf = U x 106 / (AADT x 365 x n) injury accidents per million vehicles

- For Road sections:

Uf = U x 106 / (AADT x 365 x n x L) injury accidents per million vehicles-km

U = number of reported injury accidents during the period n

n = period length (years)

L = section length (km

The next step is

- Critical crash rate:

$$\mathbf{Rc} = \mathbf{Ra} + \mathbf{confidence\ level} * \sqrt{\frac{\mathbf{Ra}}{\mathbf{MEV}} + \frac{\mathbf{1}}{\mathbf{2} * \mathbf{MEV}}} \quad \text{.....2}$$

Where,

Rc = Critical Accident Rate (accidents per million vehicles or accidents per million vehicle-km)

Ra= average crash rate

MEV= Millions vehicle-km of vehicles traversing road segment during the analysis period

$$\mathbf{MEV} = \frac{\mathbf{ADT} * \mathbf{365} * \mathbf{n}}{\mathbf{1000000}}$$

n=Number of years

Ra = Average Accident Rate (accidents per million vehicles or million vehicle-km)

- **For Road sections**

$$\mathbf{Rc} = (Average\ Crash\ Rate) + \left((K)\sqrt{\frac{\text{Average Crash Rate}}{\frac{365 \times \text{Y} \times [\text{AADT}] \times [\text{L}]}{1{,}000{,}000}}} \right) \left(\frac{1}{\frac{2[365 \times Y \times (AADT) \times (L)]}{1{,}000{,}000}} \right)$$

- **For Junctions**

$$\mathbf{Rc} = (\boldsymbol{Average\ Crash\ Rate}) + \left((\boldsymbol{K})\sqrt{\frac{\textbf{Average Crash Rate}}{\frac{\mathbf{365 \times Y \times [AADT]}}{\mathbf{1{,}000{,}000}}}} \right) \left(\frac{\mathbf{1}}{\frac{\mathbf{2[365 \times Y \times (AADT)]}}{\mathbf{1{,}000{,}000}}} \right)$$

Where,

AADT = Average annual daily traffic for the spot (for an intersection, the sum of the volumes on all approaches).

Y = Number of years being analyzed

L = Length of the segment in kilometer (for intersection L is 1).

k=Confidence level

- Compare the location's crash rate to the critical crash rate. If the location crash rate exceeds the critical crash rate, classify the location as an accident **Black Spot**.

RANKING OF SITES

For prioritizing those black spots, the ratios of accident costs by degree of severity were established by TRL (2) the weight given for fatal accident is 5, for serious injury is 3, for light injury and property damage are 2 and 1 respectively.

$$\mathbf{P} = \frac{\mathbf{1}*\boldsymbol{w}+\mathbf{2}*\boldsymbol{X}+\mathbf{3}*\boldsymbol{Y}+\mathbf{5}\boldsymbol{Z}}{\boldsymbol{D}}$$

Where:

P=Priority value;

w= total number of property damages;

X= total number of light injuries;

Y = total number of serious injury;

Z = total number of fatalities; and

D = total number of distance of the black spot section in kilometer

CHAPTER FOUR
FINDINGS AND DISCUSSION

This chapter presents the findings of the study followed by discussions .It is very important to note that the years indicated in the analysis part, except years of reference materials, are referred to in Ethiopian calendar.

4.1. Major Factors Contributing to Road Traffic Accidents in Addis Ababa

This section focuses on the identification and analysis of the major factors contributing to the problem of road traffic accidents particular focusing on driver, pedestrian, and passenger's sex and age casualties in Addis Ababa in general and Akaki-Kaliti Sub-City roads in particular .

4.1.1. Drivers Factors by Sex and Age

4.1.1.1. Drivers factors by sex

Most of the time, the major contributing factor in the majority of traffic accidents is the behavior of the drivers; hence, worldwide studies such as those of the OECD show that about 80-90% of the road traffic accidents are attributed to the fault of the drivers, and majority of them are male drivers (Bitew, 2002). Similarly, the analysis results in Table 4.1 confirm that about 94% of the driver errors are caused by male drivers, and only female drivers caused the remaining 6% of road traffic accidents during 2001-2005 in Addis Ababa City Administration. Moreover, from the 94% of road accidents caused by male drivers, about 15.3%, 42%, and 36.7% represented fatalities, serious injuries and slight injures respectively in the City. Correspondingly, the female drivers' road traffic accident casualties were minimal, i.e., only about 3.6% and 2.4% of serious and slight accidents were reported respectively in the year between 2001 and 2005, with no fatalities. In agreement to the data collected from the Addis Ababa Road and Transport Office, it showed that driving license holders are about 365,335 97 (74%) male and 128, 032 (26%) female up to 2005.

Chi-square test was conducted to observe gender participation in road accidents result of sex of the drivers and frequency of accident. It shows the male participants were involved in accident more than the female participants in the last five-year period in Addis Ababa City Administration with p value<0.05.

Table 4.8 Chi-square Test Calculation Results

Sex of the drivers	Observed frequency	Expected frequency	d.f.	Critical χ^2	Calculated χ^2
Male	392	308.6	1	3.841	86.736
Female	25	108.4			
Total	417				
		Significant value		0.05	.000

Table 4.9: Cross tabulation of Drivers' sex with Accident level in Addis Ababa City Administration

Sex of driver * Accident level Cross tabulation

			Accident level			Total
			death	serious injury	light injury	
Sex of driver	male	Count	64	175	153	392
		% of Total	15.3%	42.0%	36.7%	94.0%
	female	Count	0	15	10	25
		% of Total	0.0%	3.6%	2.4%	6.0%
Total		Count	64	190	163	417
		% of Total	15.3%	45.6%	39.1%	100.0%

Consequently, in agreement with the above analysis, the Chi-Square Test result confirms that the presence of statistically significant difference among male and female drivers in causing road traffic accidents in the City at probability level of *p (0.000)* and with Chi-Square value of 86.736. Meaning, the more the probability level approaching to 0.000 and the chi square value greater than the critical value of 95% confidence interval i.e., 3.841, show the presence of significant effects between the cross-tabulated variables, in this case accident and sex of drivers (see Table **4.8**, Table **4.9**, and Figure **8** for the details).

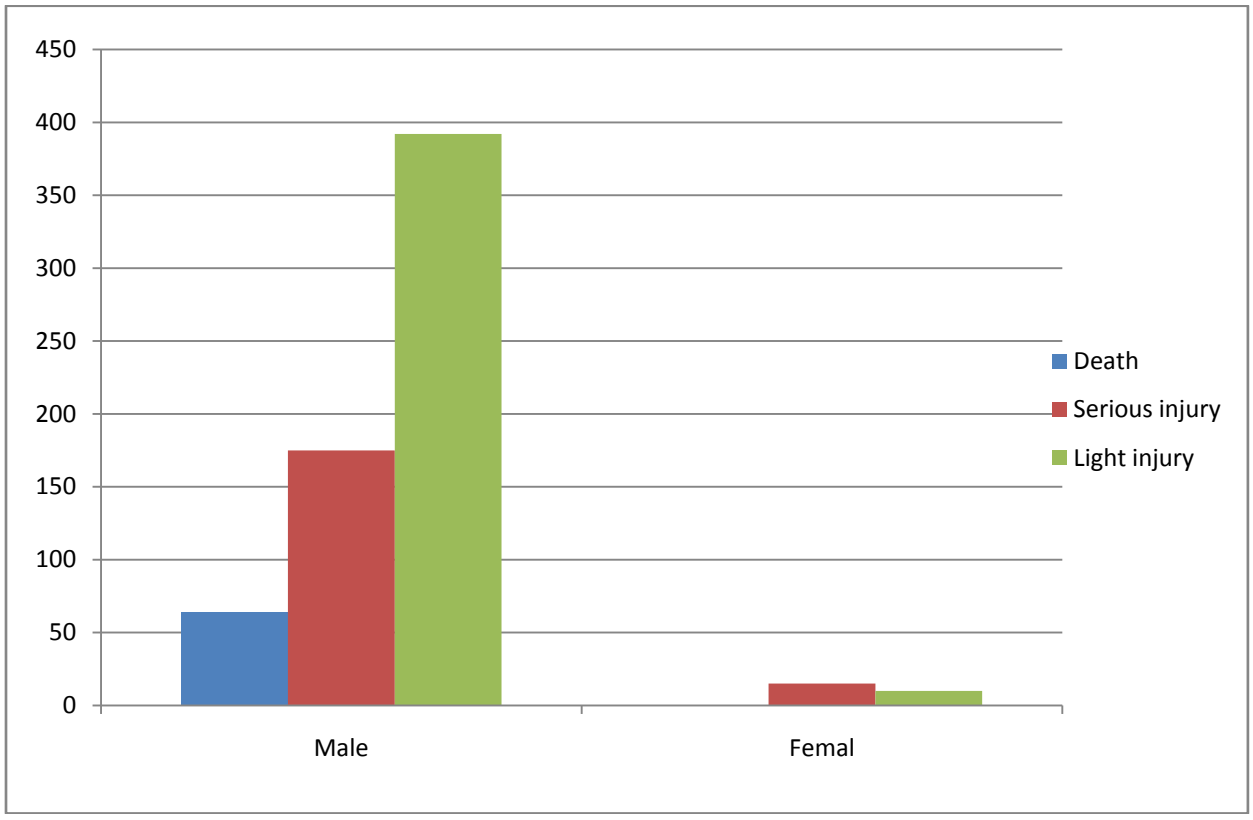


Figure 8: Comparison of RTA casualties (sufferer) in Addis Ababa City Administration by their Sex

4.1.1.2. Drivers factors by age in Addis Ababa City Administration

Table **4.10** and table **4.11** below elaborate the age distribution of the drivers and its associated effects on the levels of Road Traffic Accidents in Addis Ababa. Accordingly, about 1.4%, 42%, 43.9%, and 12.7% of the reported driver casualties have an age of < 18, 18-30, 31-50, and >50 years respectively. When drivers' accident victims were compared by their age category, those drivers with an age less than 18 years old are the lesser affected age category since acquiring driving license considers at minimum of 18 years. In contrary, drivers with an age greater than 18 years, but less or equal to 50 years were the most affected drivers in RTAs in all categories of RTA classifications. For instance, 7.7% and 5.5% of the drivers with ages of 18-30 and 31-50 years respectively were found in death report. Generally, the current study concluded that the number of drivers who suffered in deaths, serious injuries and light injuries have decreased as the age of drivers becomes above 50 years old as shown in Table **4.11**.

Table 4.10: Chi-Square test results by age group of the drivers and frequency of accident (2001-2005)

Age group of the drivers	Observed frequency	Expected frequency	d.f.	Critical χ^2	Calculated χ^2
<18	6	104.3	3	7.815	225.293
18-30	175	104.3			
31-50	183	104.3			
>50	53	104.3			
Total	417				
			Sig.	0.05	.000

Table 4.11: Chi-Square Test Results for Independent test drivers' casualties by age with Accident Level in Addis Ababa City Administration (2001-2005)

Drivers casualties			Accident Level			Total
			Death	Serious Injury	Light Injury	
Age categorized	<18	Count	3	3	0	6
		%	0.7%	0.7%	0.0%	1.4%
	18-30	Count	32	88	55	175
		%	7.7%	21.1%	13.2%	42.0%
	31-50	Count	23	77	83	183
		%	5.5%	18.5%	19.9%	43.9%
	>50	Count	6	22	25	53
		%	1.4%	5.3%	6.0%	12.7%
Total		Count	64	190	163	417
		%	15.3%	45.6%	39.1%	100.0%
Chi-Square Tests		***Value***	***16.418***			
		Sig.	***.012***			

Furthermore, the above, ***Chi-Square Tests*** results corroborate the presence of significant difference on the level of the accidents, based on the given age category of the drivers at *p (0.021)* and chi-square value of *16.42*. This magnifies that the effect of age on the type and level of occurrences of the road traffic accidents in the city is tremendous and likely changes with the age of the drivers. To put it in other words, the magnitude of drivers' sufferers in RTAs including

death and serious injury reached maximum level between 18-30 years and the light injury maximum level between 31-50 years for light injury (see Figure **9**), and then after it start declining for the three mentioned accident types and levels. Meaning, the study result emphasizes that as the age of the drivers' increases, the road traffic accident conversely decreases. In addition, graphical sketch in both death and serious road traffic accidents associates with similar drivers' age category to begin risk reductions. It is possible that aged drivers have more experience and probably much more responsibility than youths (see Figure **9** for the details).

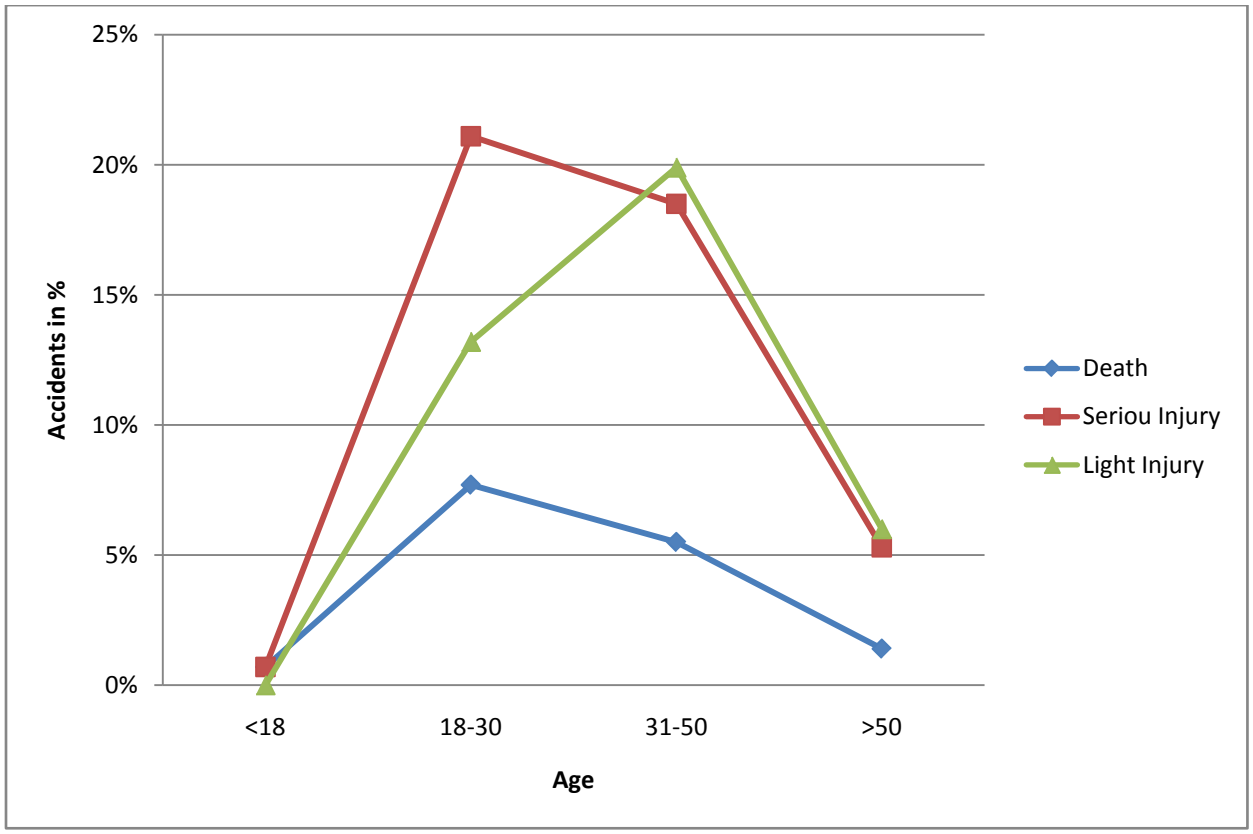


Figure 9: Comparison of accident types by Drivers Age (2001-2005) in Addis Ababa City Administration

Besides the above figure, the results of the analysis on the number of drivers' victimized by road traffic accidents, 2001-2005, has shown the occurrence of very high fatalities in 2005, followed by 2001and 2002 respectively. Whereas, the magnitude of the occurrences of serious accidents in the city was very significant in year 2001, 2004, and 2005, respectively. Similarly, light injuries were significant in year 2001, 2004, and 2005 respectively as shown in Figure **10**.

In general, the trends of victimized drivers' sufferers from RTAs had shown increments from year 2001 to 2005, and the highest percentages of drivers who were involved in accidents were between the ages of 18 and 50. This trend shows that aged drivers are more careful on traffic safety than youth below 50 years old; it is possible that aged drivers have more experience and probably much more responsibility than youths. In addition, it is also possible to say that youth behaviors towards traffic safety is poor due to peer groups suggestion and influence on driving style and encourage taking risks within such age. However, young drivers could be more endurance, for instance, to driving larger distances than elder drivers.

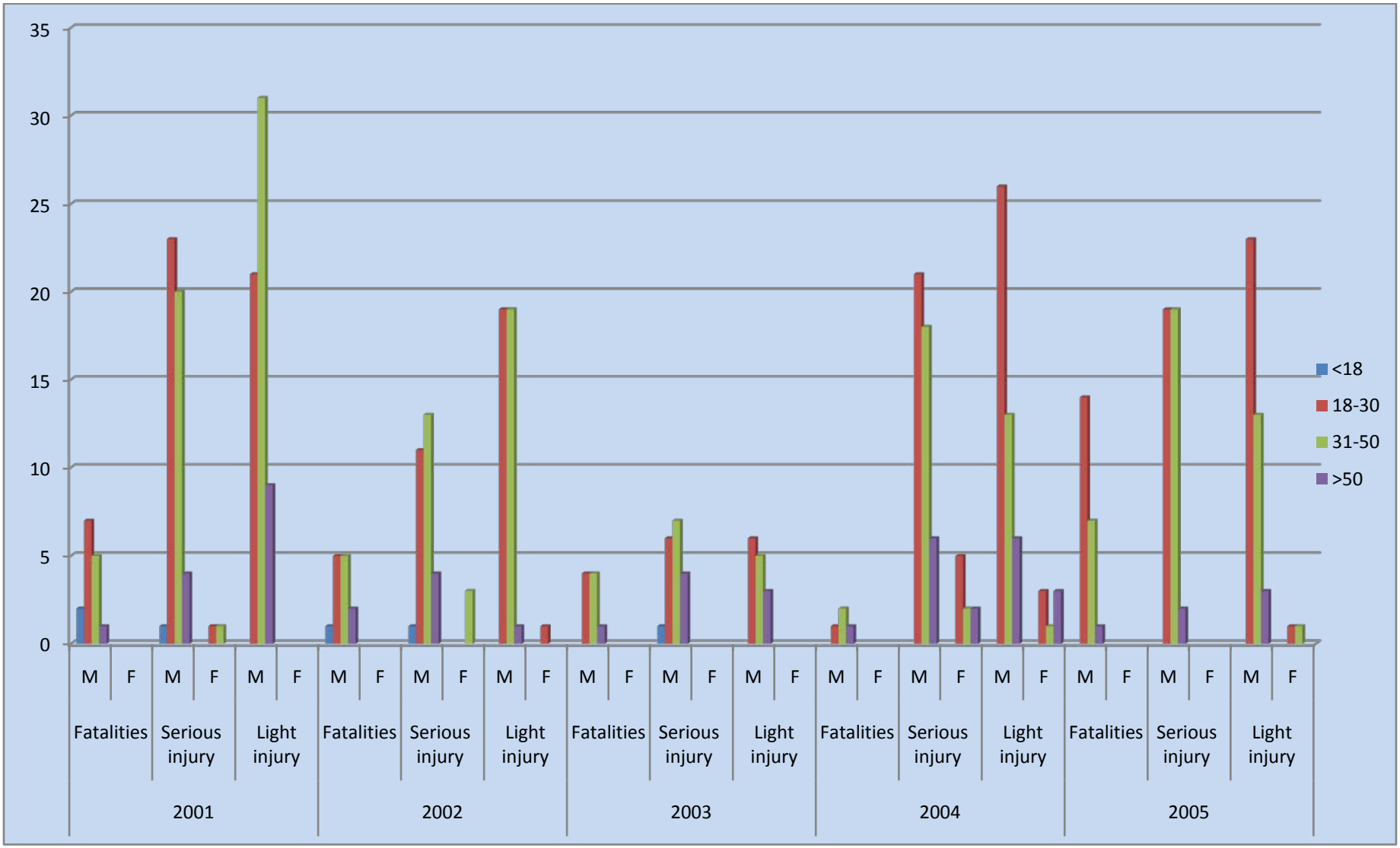
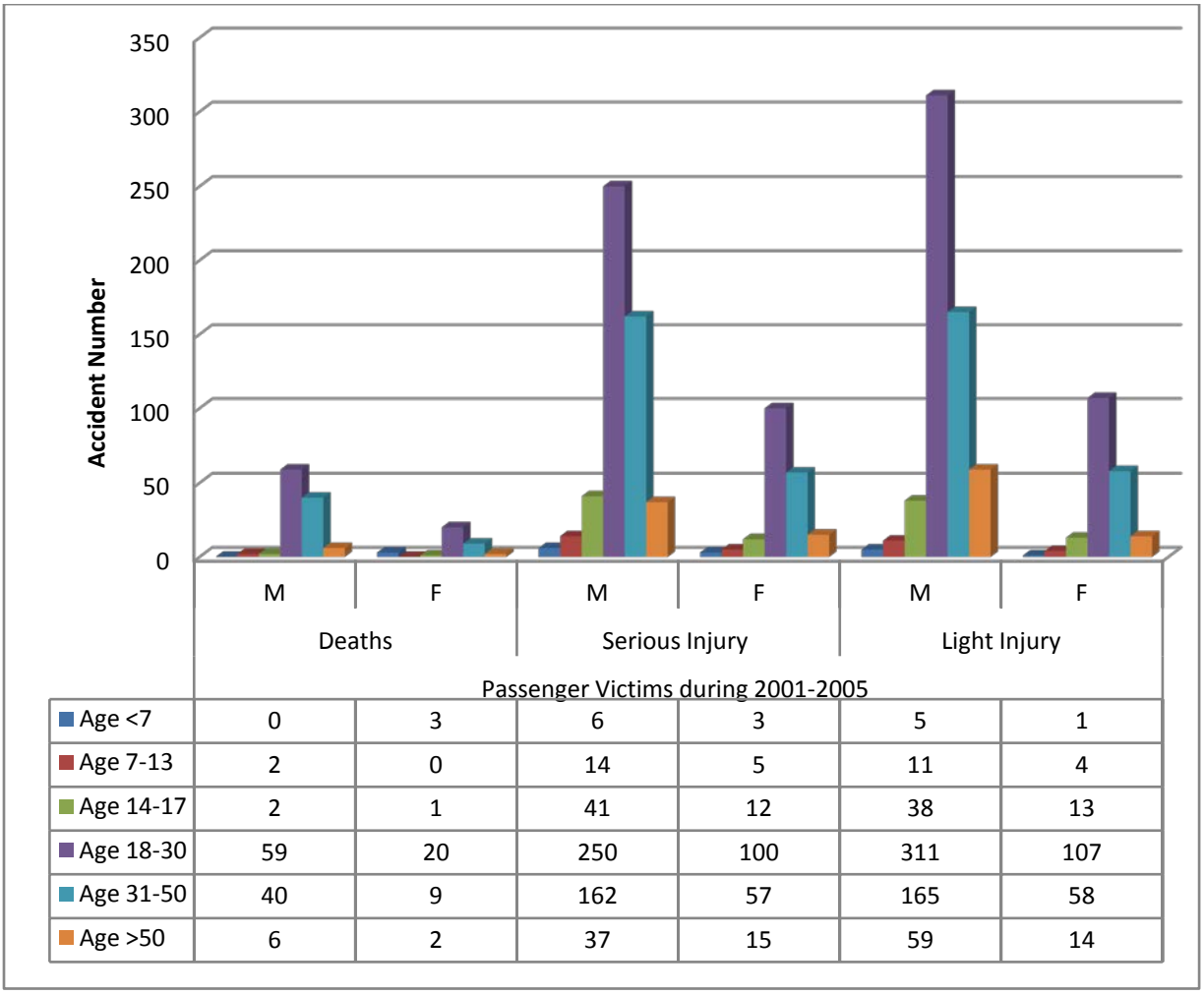


Figure 10: Drivers casualties during 2001-2005 in Addis Ababa City Administration

4.1.2. Passenger Victims in Addis Ababa city Administration

Passengers are other important victims of road traffic accidents in Addis Ababa City Administration (see Figure **11**). Accordingly, the passengers whose age is between 18-30 are the major affected groups by road traffic accidents in the city during 2001-2005 followed by passengers whose age is between 31 and 50 in the same years. In contrast, passengers with an age of less than 7 are the smallest sufferers of road traffic accidents in 2001 to 2005.



Age <7	0	3	6	3	5	1
Age 7-13	2	0	14	5	11	4
Age 14-17	2	1	41	12	38	13
Age 18-30	59	20	250	100	311	107
Age 31-50	40	9	162	57	165	58
Age >50	6	2	37	15	59	14

Figure 11: Passengers Victims during 2001-2005 in Addis Ababa City Administration

Moreover, the analysis of the study confirms that there are more number of male passengers' victims than the female counterparts at all accident levels and types between 2001 and 2005 in the City. For example, large number of passengers' deaths, serious injuries, and light injuries

were reported to males compared as female passengers. Shockingly, the most affected female passengers in road traffic accidents was between 2001 and 2005 in the city were younger productive groups, i.e., those between the ages of 18 and 30, followed by 31-50 years of age categories shown in Figure **11**. Generally, the trends of RTAs in all the three categories which include death, serious injury, and slight injury for both sexes in 18-30 and 31-50 age categories had disclosed increment as shown in Table **4.13**, and Figure **12**. Table **4.12** below shows the ***Chi-Square Tests*** results which confirmed the presence of significant difference on the accidents based on the given age category.

Table 4.12: Chi-square test result of Age of passenger victims and frequency of accident

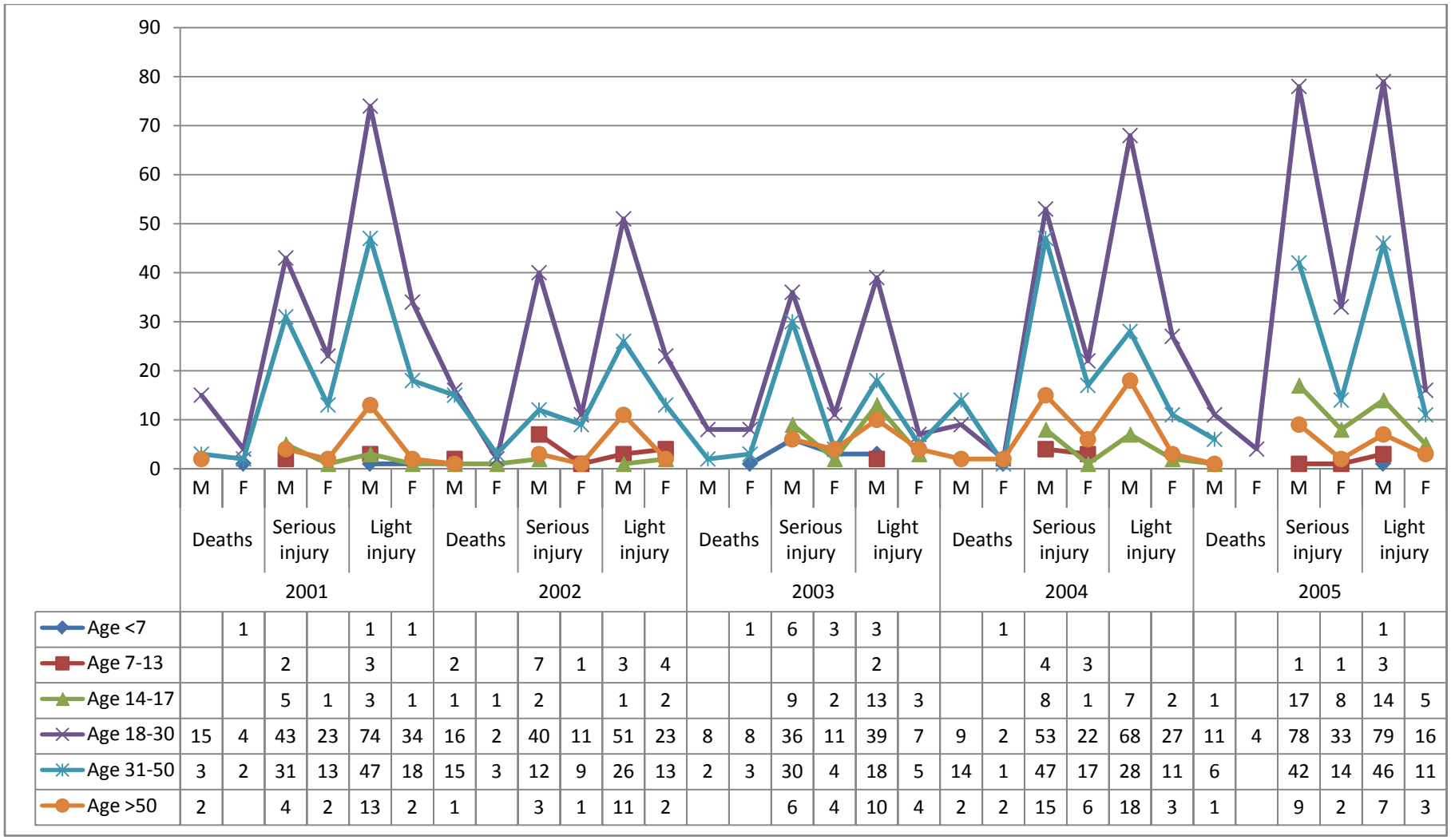
age of the Passengers	Observed frequency	Expected frequency	d.f.	Critical χ^2	Calculated χ^2
<7	18	168.1	5	11.070	446.965
7-13	36	194.2			
14-17	107	168.1			
18-30	847	584.3			
31-50	491	367.2			
>50	133	150.1			
Total	1632				
			Sig.	0.05	. 000

Table **4.12** shows a calculated χ 2 - value of 446.965 for 5 df. Moreover, a critical χ 2 - value of 11.070 at 0.05 alpha levels since the calculated χ 2 - values is greater than the critical χ 2 - value. The null hypothesis independency between the accident and age of the passengers is rejected at p value < 0.05. There is a statistically significant difference and it is evident that the accident is highly related with passengers' age.

Table 4.13: Cross tabulation of Passenger victims with Accident type in Addis Ababa City Administration

Age-group * Accident type level Cross tabulation

			Accident level			Total
			Death	Serious injury	Light injury	
Age-group	<7	Count	3	9	6	18
		% of Total	0.2%	0.6%	0.4%	1.2%
	7-13	Count	2	19	15	36
		% of Total	0.1%	1.2%	0.9%	2.2%
	14-17	Count	3	53	51	107
		% of Total	0.2%	3.2%	3.1%	6.5%
	18-30	Count	79	350	418	847
		% of Total	4.8%	21.4%	25.6%	51.9%
	31-50	Count	49	219	223	491
		% of Total	3.0%	13.4%	13.7%	30.1%
	>50	Count	8	52	73	133
		% of Total	0.5%	3.2%	4.5%	8.2%
Total		Count	144	702	786	1632
		% of Total	8.8%	43.0%	48.2%	100%

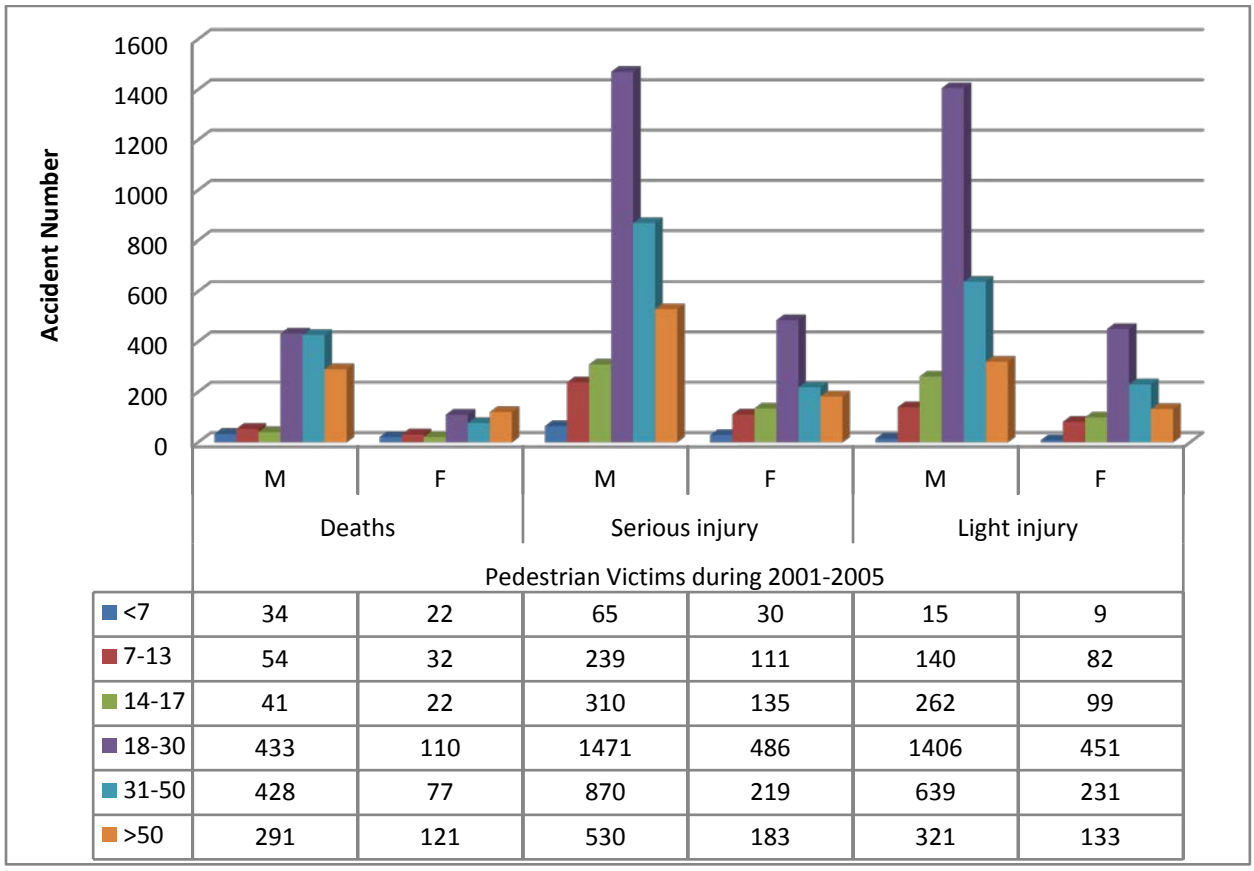


	2001						2002						2003						2004						2005					
	Deaths		Serious injury		Light injury		Deaths		Serious injury		Light injury		Deaths		Serious injury		Light injury		Deaths		Serious injury		Light injury		Deaths		Serious injury		Light injury	
	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
Age <7		1			1	1								1	6	3	3			1									1	
Age 7-13			2		3		2		7	1	3	4					2				4	3					1	1	3	
Age 14-17			5	1	3	1	1	1	2		1	2			9	2	13	3			8	1	7	2	1		17	8	14	5
Age 18-30	15	4	43	23	74	34	16	2	40	11	51	23	8	8	36	11	39	7	9	2	53	22	68	27	11	4	78	33	79	16
Age 31-50	3	2	31	13	47	18	15	3	12	9	26	13	2	3	30	4	18	5	14	1	47	17	28	11	6		42	14	46	11
Age >50	2		4	2	13	2	1		3	1	11	2			6	4	10	4	2	2	15	6	18	3	1		9	2	7	3

Figure 12: Passengers casualties in Addis Ababa City Administration by individual Year, age group, and sex

4.1.3. Pedestrian Casualties

Road traffic accident is highly affecting the population of developing countries population from which pedestrian are the most affected. Hence, they lack appropriate road traffic knowledge. The problem caused seriously affect their family and the community at large. Similarly, the road traffic accidents affect the pedestrian in the cities like Addis Ababa where the road traffic infrastructure and efficient roads are inadequately available, and notably mentioned as among the worst social problems. Accordingly, the current study showed that the majority of the death reports are on the male pedestrians is with in the group of age 18-30 and 31-50, which are followed by ages greater than 50 years. Similarly, high death reports of female pedestrians with an age 18-30 and greater than 51 years respectively. These confirms that most of road traffic accidents were highly affecting the economically active citizens i.e., youths and young adult groups. This, in turn, negatively affects the economy of the country and social structure of the population in the Addis Ababa. Figure **13** shows pedestrian casualties in Addis Ababa



	M	F	M	F	M	F
<7	34	22	65	30	15	9
7-13	54	32	239	111	140	82
14-17	41	22	310	135	262	99
18-30	433	110	1471	486	1406	451
31-50	428	77	870	219	639	231
>50	291	121	530	183	321	133

Figure 13: Pedestrian casualties in Addis Ababa City Administration

Moreover, the serious injures highly affect the male pedestrians whose age is between 18-30 years old than any other age categories. In the same way, the male pedestrians who have an age greater than 51 years also severely affected though the magnitude is less than 31-50 years. From the light injures perspectives, similar trends were observed since pedestrians whose age is between 18-30, and 31-50 were affected more as compared to the others. The general observation was that males were more involved in road accidents because they travel more in their daily duties when compared with many females who usually stay at home doing domestic duties.

Table 4.14: Chi-square test result of age of pedestrian victims and observed frequency of accident

age of the Pedestrian	Observed frequency	Expected frequency	d.f.	Critical χ^2	Calculated χ^2
<7	175	1040.5	5	11.070	1616.246
7-13	658	1202.1			
14-17	869	1040.5			
18-30	4357	3616.5			
31-50	2464	2273.0			
>50	1579	929.4			
Total	10102				
			Sig.	0.05	.000

Since *p*-value = 0.000 ≤ 0.05, we shall reject the null hypothesis
Chi-square=1616.246>11.070=critical Chi-Square value

According to table **4.14,** the null hypothesis of independence between the age of the pedestrian and distribution of accident is rejected at p-value<0.05. It is evident that the accident is highly related to age of the pedestrian.

Table 4.15: Chi-square test and cross tabulation result of age of pedestrian victims and level of accident

Age-group * Accident level Cross tabulation

			Accident level			Total
			Death	Serious injury	Light injury	
Age-group	<7	Count	56	95	24	175
		% of Total	0.6%	0.9%	0.2%	1.7%
	7-13	Count	86	350	222	658
		% of Total	0.9%	3.5%	2.2%	6.5%
	14-17	Count	63	445	361	869
		% of Total	0.6%	4.4%	3.6%	8.6%
	18-30	Count	543	1957	1857	4357
		% of Total	5.4%	19.4%	18.4%	43.1%
	31-50	Count	505	1089	870	2464
		% of Total	5.0%	10.8%	8.6%	24.4%
	>50	Count	412	713	454	1579
		% of Total	4.1%	7.1%	4.5%	15.6%
Total		Count	1665	4649	3788	10102
		% of Total	16.5%	46.0%	37.5%	100.0%
Chi-Square Tests		***Value***	***347.171***			
		Sig.	***.000***			

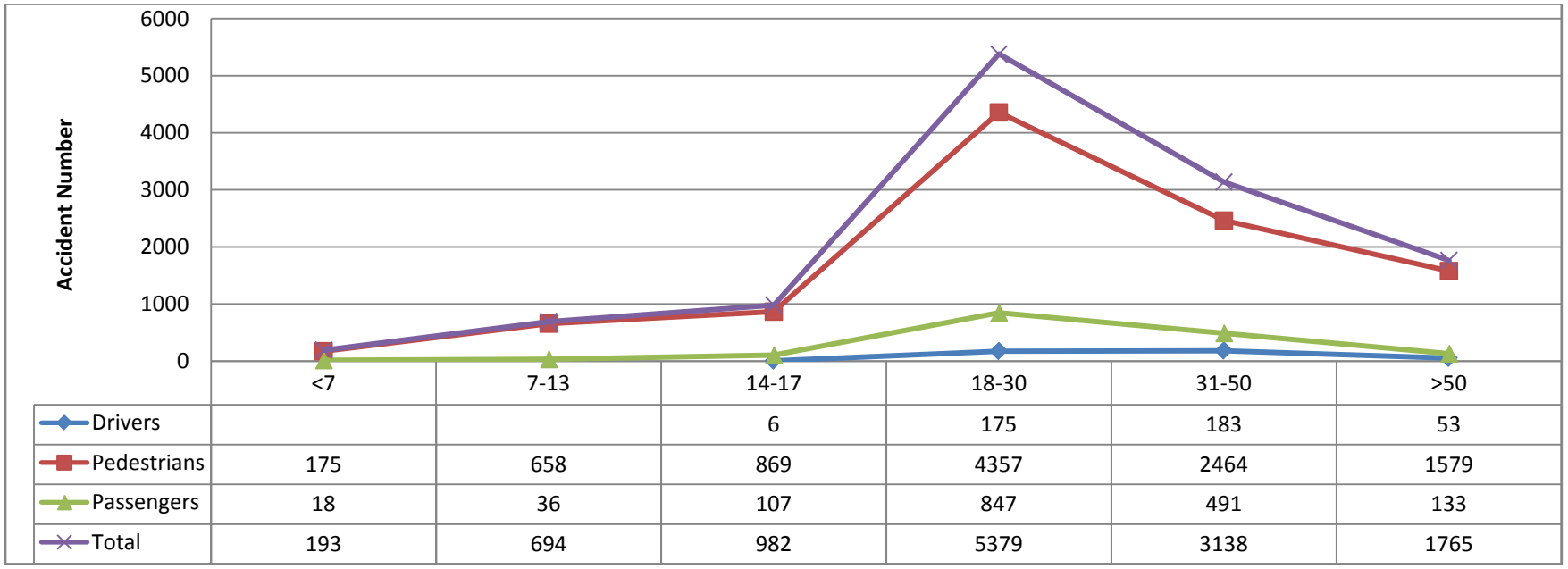
Furthermore, in agreement with the above descriptive statistics of Figure **13** ,table **4.16** ***Chi-Square Tests*** result endorse the presence of significant difference on the level of the accidents basing the given age category of the Pedestrian at *p (0.000)* and chi-square value of *347.171*. These confirm that most of road traffic accidents highly and adversely affect the economically active citizens i.e., youths and young adult groups.

Table 4.16: Chi-square test result of sex of pedestrian victims and accident level

			Accident level			Total
			death	serious injury	light injury	
Sex of causality	male	Count	1281	3485	2783	7549
		% of Total	12.7%	34.5%	27.5%	74.7%
	female	Count	384	1164	1005	2553
		% of Total	3.8%	11.5%	9.9%	25.3%
Total		Count	1665	4649	3788	10102
		% of Total	16.5%	46.0%	37.5%	100.0%
Chi-Square Tests		***Value***	***7.617***			
		Sig.	***.022***			

Results in Table **4.16** confirm the presence significant difference between sexes of causalities (male and female) and accident level of pedestrians victims' in road traffic accidents in the City at probability level of p (0.022) and with **Chi-Square** value of 7.617. This means, the more the probability level approaching to 0.000 and the Chi-Square value greater than the critical value of 95%, confidence interval i.e., 3.841.

SUMMARIZED ROAD USER CASUALTIES IN ADDIS ABABA CITY ADMINISTRATION BY INDIVIDUAL AGE GROUP



	<7	7-13	14-17	18-30	31-50	>50
Drivers			6	175	183	53
Pedestrians	175	658	869	4357	2464	1579
Passengers	18	36	107	847	491	133
Total	193	694	982	5379	3138	1765

Figure 14: Drivers, Pedestrians, and Passengers casualties in Addis Ababa City Administration

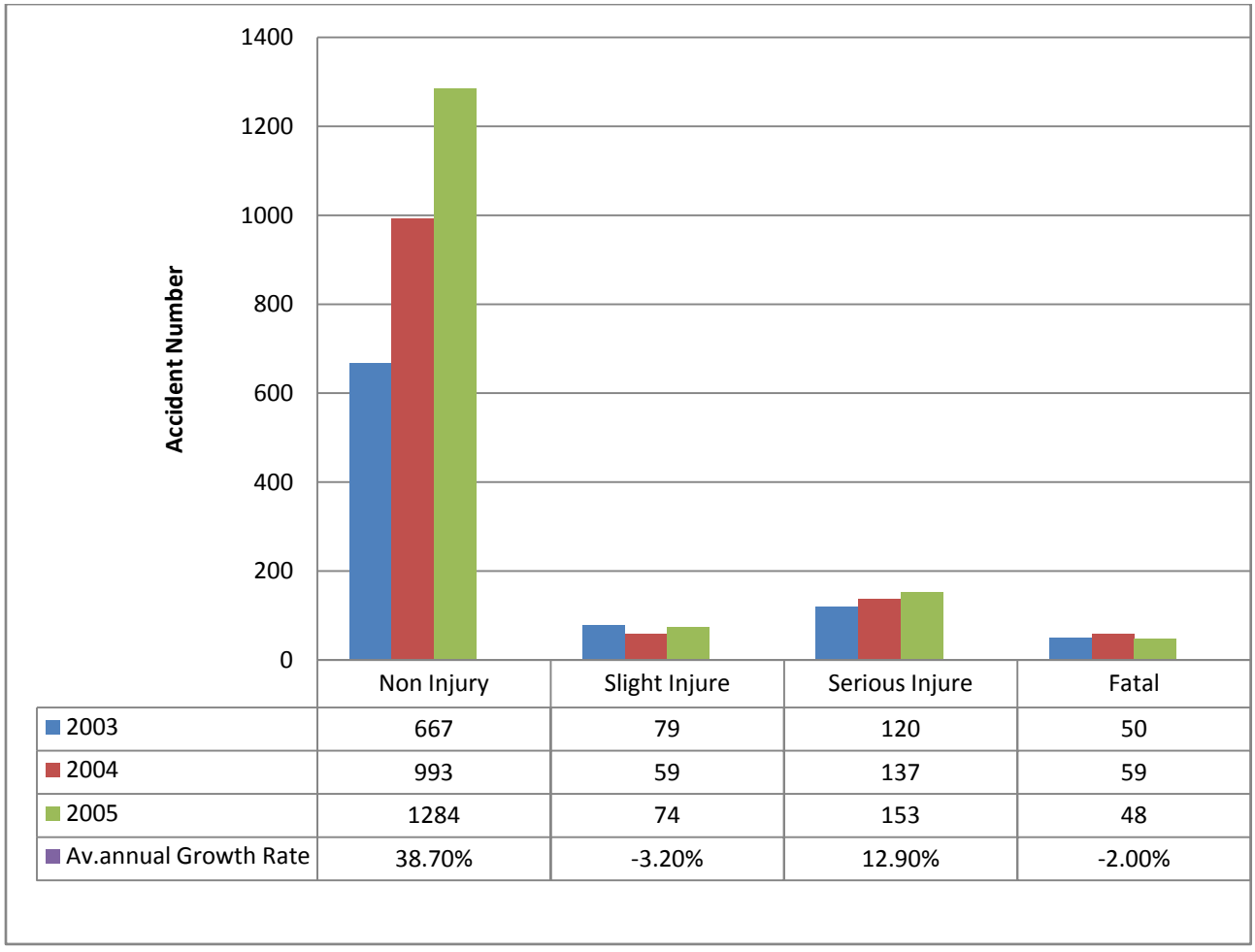
The above Figure **14** shows the distribution of road accident victims by age group. The findings show that pedestrians are more vulnerable to traffic accident in Addis Ababa, followed by passengers. Pedestrians aged 18-30; 31-50 and above 50 account for the highest percentages of accident victims than those groups who are aged below 7, 7-13 and 14-17. Generally, the magnitude of the road accident victims (drivers, pedestrians, and passengers) within the age group of 18-30 in RTAs who have age are the most affected during 2001-2005, and followed by age group of 31-50 in the same period. In contrary, road users whose age is less than 7 were the least victims of road traffic accidents during 2001 to 2005 in Addis Ababa City Administration.

4.1.4. Road traffic accidents on major roads of in Akaki-Kaliti Sub-City

In this part the researcher discusses RTAs by severity extent, day of a week, time of the accident occurred, land use, collision type, accident by road character, accident by road junction type, accident by road lane type, accident by vehicle type, road way surface condition, type of vehicle defect, and by light condition.

4.1.5. Accident severity on major roads in Akaki-Kaliti Sub-City

As shown in Figure **15** below, 667, 993 and 1284 were non-injury data in 2003, 2004, and 2005 respectively with increasing trend from year to year. Slight accidents have decreasing tendency though; serious accident rates have tremendous growth. Fatal reports, in turn, show fluctuation and start decreasing in 2005.

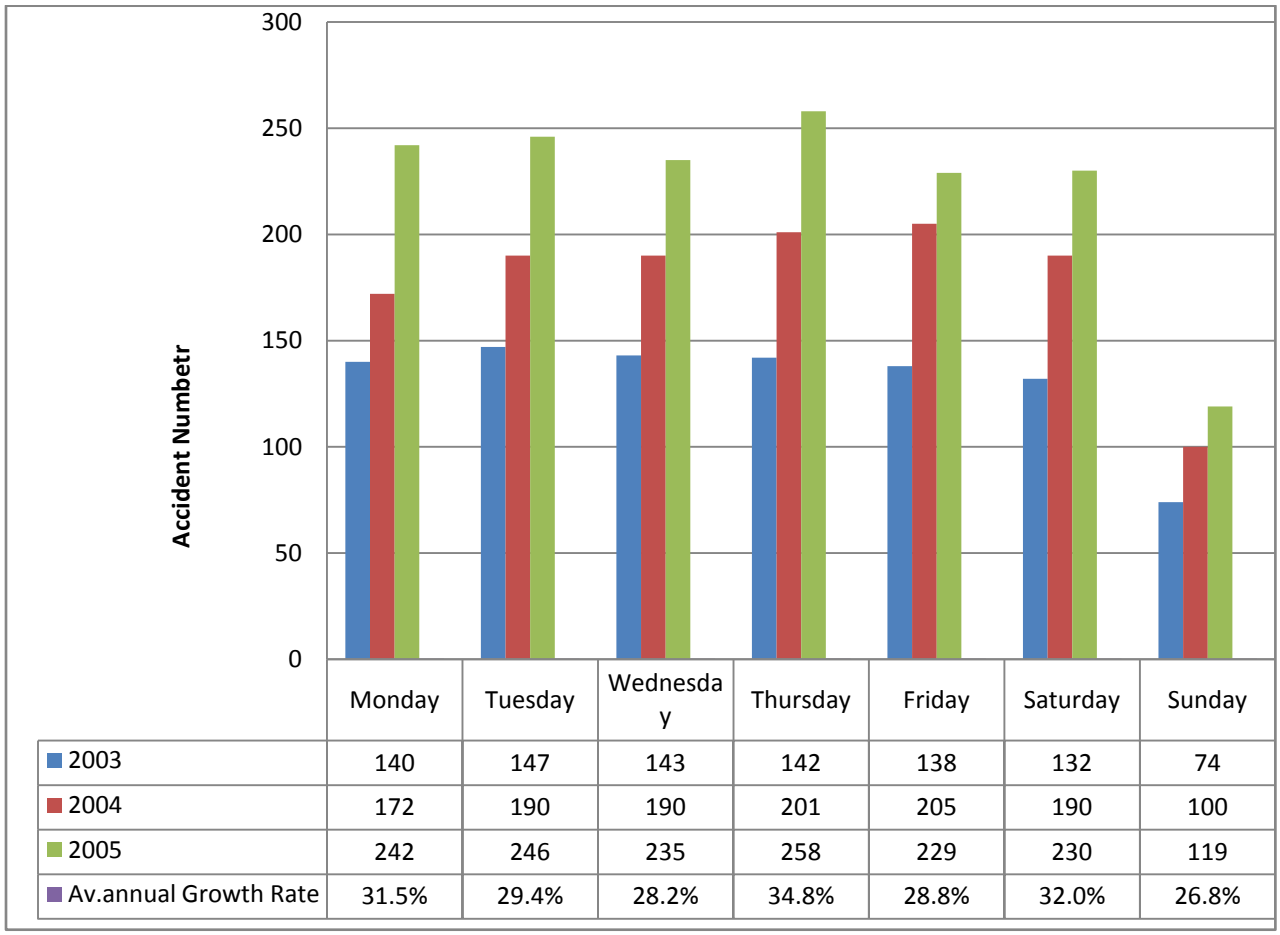


	Non Injury	Slight Injure	Serious Injure	Fatal
2003	667	79	120	50
2004	993	59	137	59
2005	1284	74	153	48
Av.annual Growth Rate	38.70%	-3.20%	12.90%	-2.00%

Figure 15: Severity type in the Sub-City

4.1.6. RTAs by day of a week in in Akaki-Kaliti Sub-City major roads

Analysis of road traffic accidents in the sub city by day of a week refers growth of the severity of the accidents from 2003 to 2005. In 2003, significant accidents were recorded in all days of the week, except on Sunday. Since, there were significant report of 147,143,142, and 140 accidents on Tuesday, Wednesday, Thursday, and Monday respectively though Sunday has very small accident. Consequently, in 2004, the highest accident crashes occurred on Friday and Thursday with report data of 205 and 201 respectively, and accident data on Tuesday, Wednesday, and Saturday recorded equal number of accidents i.e., 190. In 2005, Thursday, Tuesday, and Monday had the highest number of accidents with 258, 246, and 242 data reports respectively, and in 2003 and 2004, Sunday had relatively small accident number (see Figure 16). Generally, the analysis confirms that higher accidents occurred in the Sub-City from Monday to Saturday, especially on Tuesday, Wednesday, Thursday, and Friday.



	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
2003	140	147	143	142	138	132	74
2004	172	190	190	201	205	190	100
2005	242	246	235	258	229	230	119
Av.annual Growth Rate	31.5%	29.4%	28.2%	34.8%	28.8%	32.0%	26.8%

Figure 16: Distribution of accidents by day of a week (2003-2005)

Table 4.17: Calculation of Chi-Square

Days of Week	Observed frequency	Expected frequency	d.f.	Critical χ^2	Calculated χ^2
weekdays	2878	2658.2	1	3.841	63.535
weekends	845	1064.8			
Total	3723				
			Sig.	0.05	.000

Table 4.17 indicates that the calculated χ^2 statistics, for 1 degree of freedom is 63.54. Additionally, it indicates that the significant value (0.000) is less than the critical **p**-value of 0.05. This suggests that the null hypothesis is rejected. The alternate hypothesis is that accidents occurred on weekdays have significant difference when compared with weekends. Overall 2878 (77.3 %) of accidents occurred on weekdays with significant difference when compared with weekends (**p**-value< 0.05).

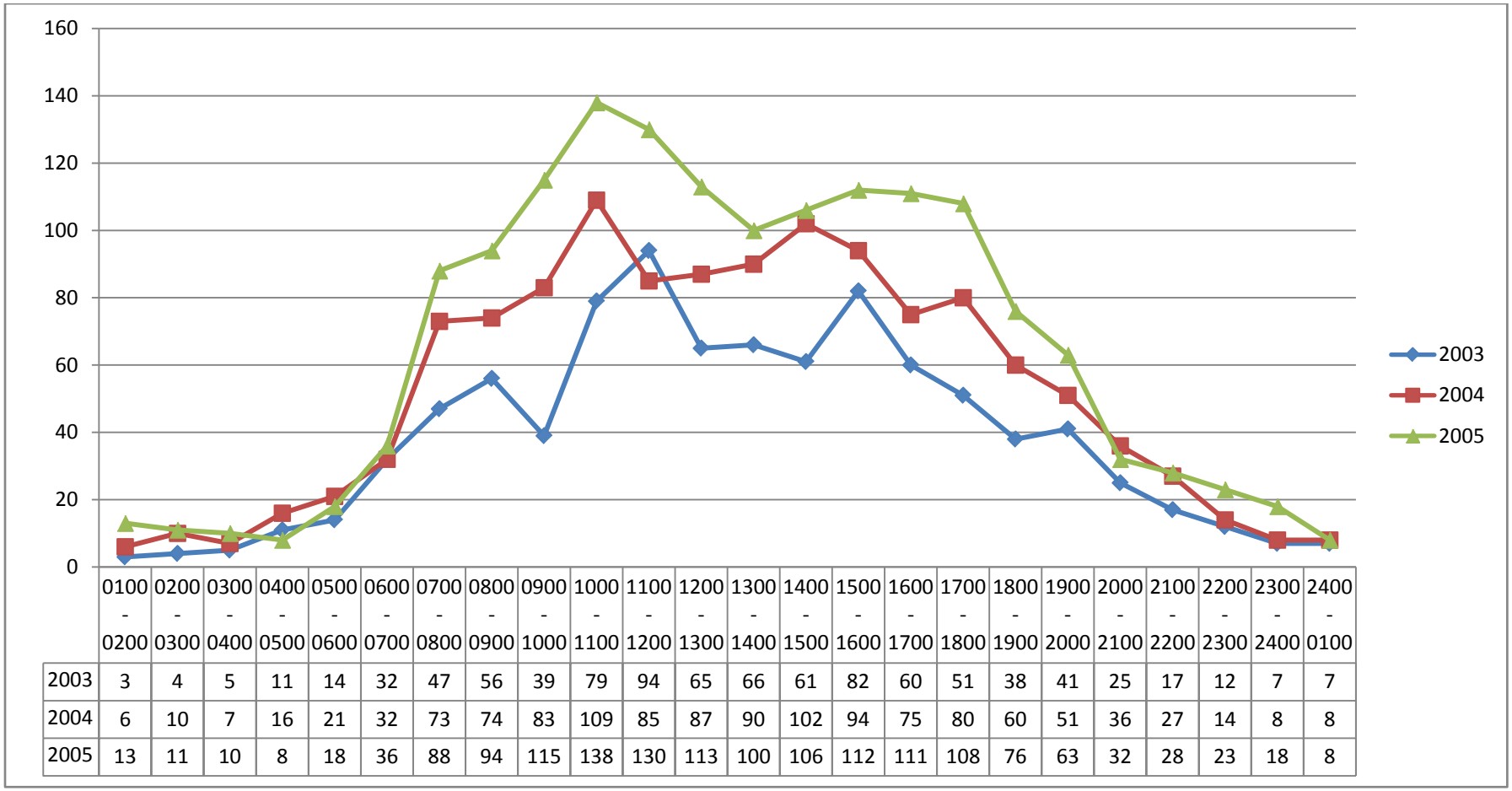
4.1.7. RTAs on major roads by hour of a day in Akaki-Kaliti Sub-City

Road traffic accidents vary by hours of a day; with maximum crashes when mobility of pedestrians, passengers, and drivers frequency increases. Accordingly, accident reports in the Sub-City by crash have three basic scenarios named by the researcher as plateau stage, maximum stage, and decreasing stages. In the first categories, 1:00 am-5:00 am accident rates more or less have similar features from 2003 to 2005. After the plateau stage especially after 6:00 am, RTAs tremendously increased and reached maximum at 10:00 am in both 2004 and 2005 and at 11:00 am in 2003. Decreasing trends of crashes per hour began with, slight decrease from 12:00 to 17:00(12 am-5 pm) in the same way in the three years, and acutely decreases after 18: 00 (6 pm) and reaches plateau levels at 24:00 (12 pm) (see Figure **18**). Hence, the accidents were highly associated with the number and time of movements of pedestrians, passengers, drivers, and vehicles.

Table 4.18: Calculation for Chi-Square accident distributed over the hours of the day.

Hours	Observed frequency	Expected frequency	d.f.	Critical χ^2	Calculated χ^2
6.00 AM - 12.00 PM	1404	930.8	3	7.815	1410.882
12.00 PM - 6.00 PM	1563	930.8			
6.00 PM - 12.00 AM	576	930.8			
12.00 AM - 6.00 AM	180	930.8			
Total	3723	Sig.		0.05	0.000

Table **4.18** shows the calculated χ^2- value of 1410.882 for 3 d.f. and a critical χ^2- value of 7.815 at 0.05 alpha level. Since the calculated χ^2- value is greater than the critical χ^2- value, the null hypothesis, i.e. accidents are uniformly distributed over the hours of the day, is rejected. Thus, it indicates that accidents are not uniformly distributed over the hours of the day. More than 79.7% of the accidents occurred during day time (6 AM to 6 PM). These times coincide with the period when people are more active and mobile. The peak time was between 12 PM to 6 PM (41.98%; Table 4). These hours are the busiest as there is heavy rush of commuters from schools, offices, factories, business places, etc. Between 6 AM to 12 PM, also a high number of RTAs i.e. 37.71% were observed (see Table **4.18**). During this period, the roads are opened for heavy vehicular movements.



	0100 - 0200	0200 - 0300	0300 - 0400	0400 - 0500	0500 - 0600	0600 - 0700	0700 - 0800	0800 - 0900	0900 - 1000	1000 - 1100	1100 - 1200	1200 - 1300	1300 - 1400	1400 - 1500	1500 - 1600	1600 - 1700	1700 - 1800	1800 - 1900	1900 - 2000	2000 - 2100	2100 - 2200	2200 - 2300	2300 - 2400	2400 - 0100
2003	3	4	5	11	14	32	47	56	39	79	94	65	66	61	82	60	51	38	41	25	17	12	7	7
2004	6	10	7	16	21	32	73	74	83	109	85	87	90	102	94	75	80	60	51	36	27	14	8	8
2005	13	11	10	8	18	36	88	94	115	138	130	113	100	106	112	111	108	76	63	32	28	23	18	8

Figure 17: Number of crashes / by hour of a day for major roads of the sub-city during 2003-2005

4.1.8. RTAs by land use in Akaki-Kaliti Sub-City major roads

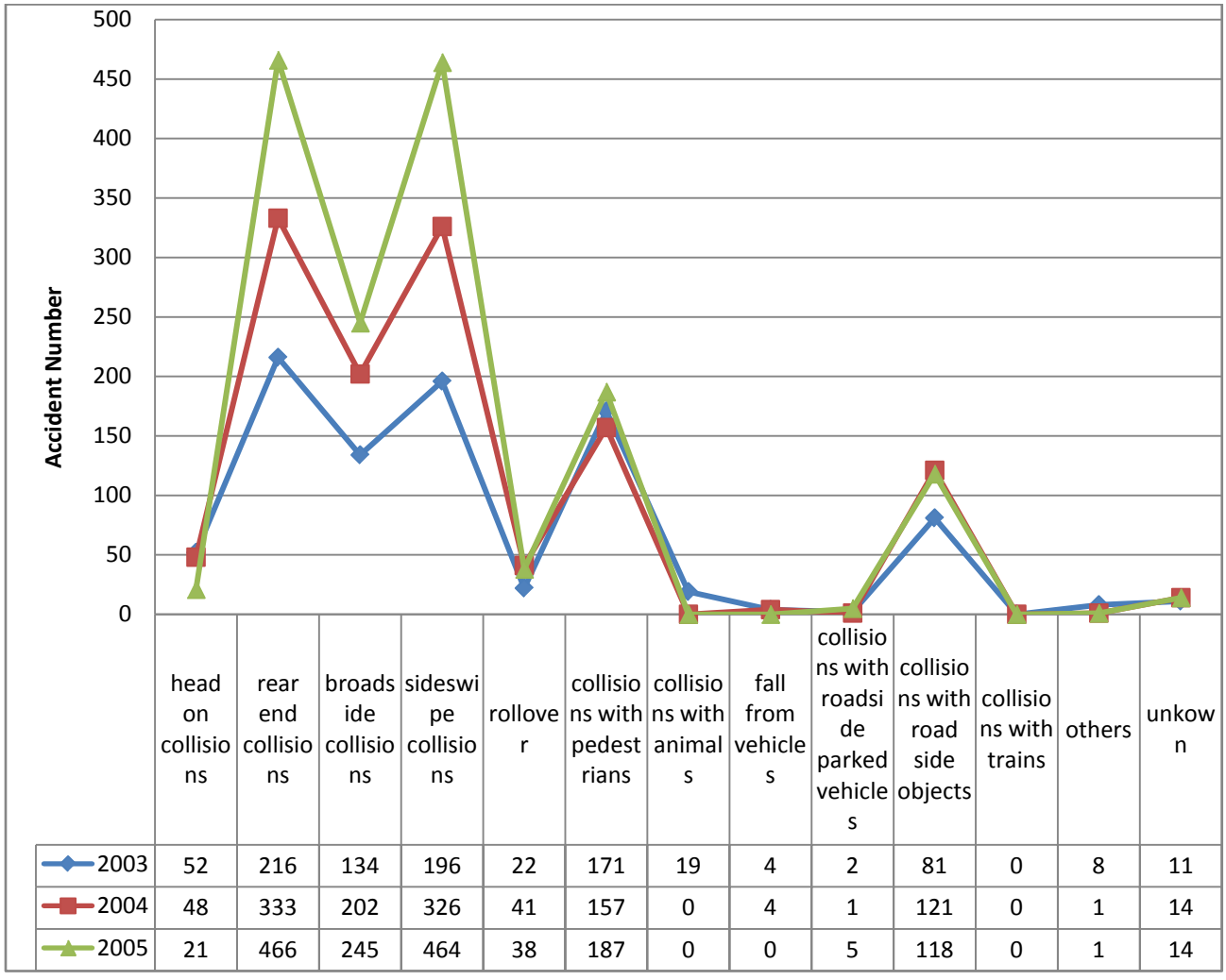
Land uses of the Sub-City are divided into Rural Village Area, Agricultural Area, School Area, Industrial Area, Church Areas, Market Areas, Recreation Area, Hospital Area, CBD (Central Business District),Urban Residential and Other types of land uses in order to examine the accident extents in each area. Accordingly, as the data collected confirm that land uses like Rural Village Area and Agricultural Area have no accident reports in all the three selected years. Whereas, CBD and Market Areas have very frequent accidents. CBD areas have accidents of 657, 1143 and 1544 in 2003, 2004 and 2005 respectively. Similarly, in Market areas, there were accident reports of 119, 38, and 5 in 2003, 2004, and 2005 respectively. The remaining selected land uses have medium level of accidents, and hence the study confirmed the presence of significant difference in exhibiting road traffic accidents in the Sub-City.

Table 4.19: Accidents by Land use

Land Use	Akaki-Kaliti Sub-City (2003-2005)			
	2003	2004	2005	2003-2005
Rural Village Area	0	0	0	0
Agricultural Area	0	0	0	0
School Area	12	10	2	24
Industrial Area	9	3	0	12
Church Areas	39	25	3	67
Market Areas	119	38	5	162
Recreation Area	18	11	3	32
Hospital Area	12	2	0	14
CBD	657	1143	1544	3344
Urban Residential	46	16	2	64
Other	4	0	0	4
Total	916	1248	1559	3723

4.1.9. RTAs By Collision Type in Akaki-Kaliti Sub-City Major Roads

The collision type is often a good indication of crash contributing factors. collisions like rear end, sideswipe, broad side, and collision with pedestrian are the most dominant type of collisions which frequently occurred in the sub city with values of 216,333, 466; 196, 326, 464 ,134, 202, 245; and 171,157,187 in the 2003, 2004 , and 2005 respectively. Whereas, collision types like collision with animals, fall from vehicles, roadside vehicle parking, and others have very low number of accident reports. The remaining head on collisions also have relatively medium accident rates.

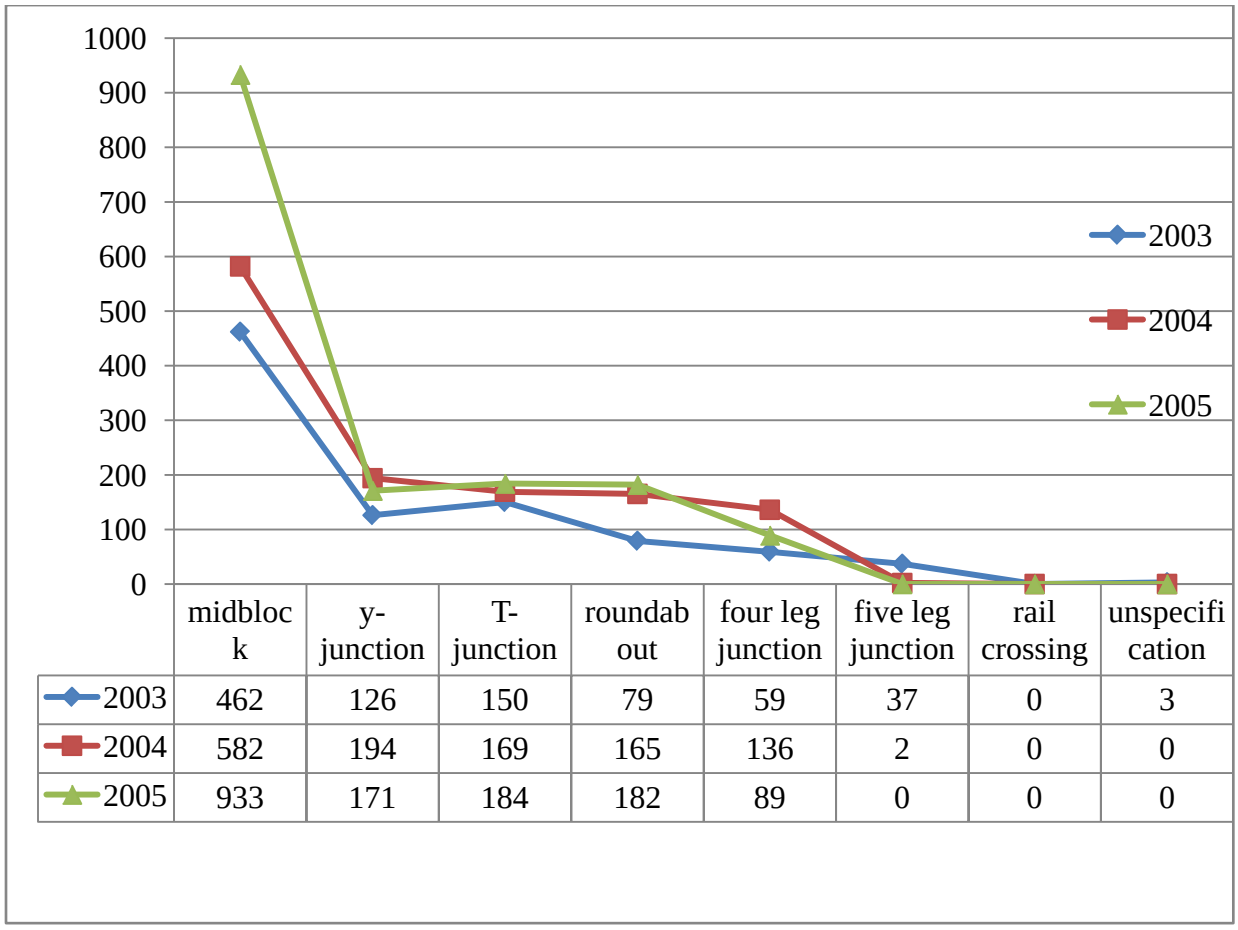


	head on collisions	rear end collisions	broadside collisions	sideswipe collisions	rollover	collisions with pedestrians	collisions with animals	fall from vehicles	collisions with roadside parked vehicles	collisions with road side objects	collisions with trains	others	unknown
2003	52	216	134	196	22	171	19	4	2	81	0	8	11
2004	48	333	202	326	41	157	0	4	1	121	0	1	14
2005	21	466	245	464	38	187	0	0	5	118	0	1	14

Figure 18: RTAs by collision type

4.1.10. RTAs by road junction in Akaki-Kaliti Sub-City Major Roads

Road junctions are categorized into different types including midblock, Y-junction, T-junction, roundabout, four-leg junction, five-leg junction, and rail crossing. In this regard, midblock junction has the highest and most frequent accident rates as compared to the other junctions with significant increment from 2003-2005. The Y– junction and T – junctions also have very adequate/significant accidents in the sub-city. The frequency accidents in the case of Y– junction were, 126; 194; 172, in 2003, 2004, and 2005 and in the case of T – junctions the corresponding number of accidents were 150; 169; 184. The remaining junction types like roundabout, four-leg junctions also have optimum level of accident number, though, and five-leg junction has low accidents in the Sub City. As we all known, rail-crossing accidents is zero since train service has not yet been started. Figure **19** Shows road traffic accidents in Akaki-Kaliti Sub-City between 2003 and 2005.

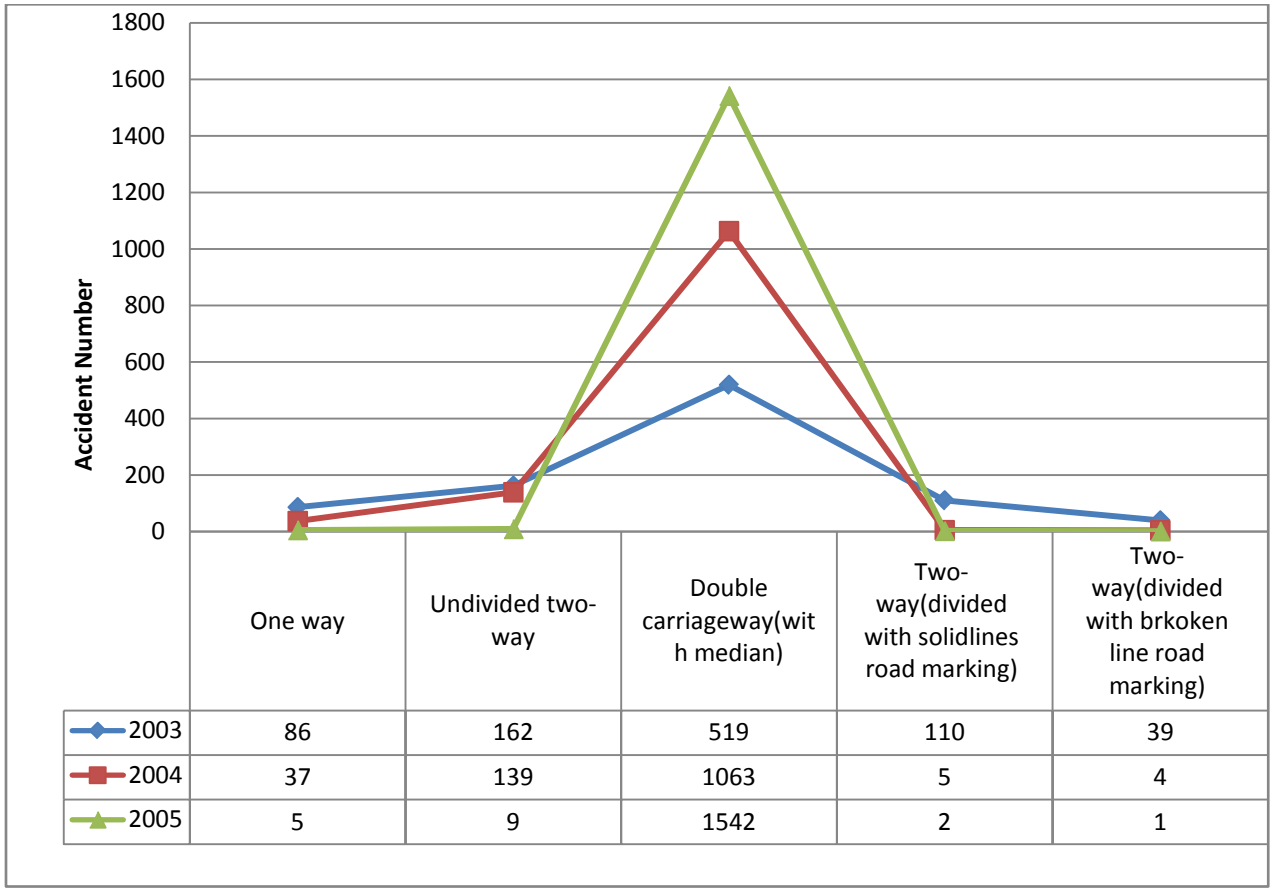


	midblock	y-junction	T-junction	roundabout	four leg junction	five leg junction	rail crossing	unspecification
2003	462	126	150	79	59	37	0	3
2004	582	194	169	165	136	2	0	0
2005	933	171	184	182	89	0	0	0

Figure 19: RTAs by junction type in the Sub-City (2003-2005)

4.1.11. RTAs by road lane in Akaki-Kaliti Sub-City Major Roads

Road lane type and quality have crucial importance in reducing road traffic accidents. In this regard, the analysis of the data illustrated in Figure **20** below shows the presence of significant difference in exhibiting road traffic accidents within lanes and between years. Accordingly, the highest frequency of accidents were associated with double carriage way (with median) with total number of 519, 1063 and 1542 in 2003, 2004 and 2005 respectively followed by undivided two-way lane with accidents of 162 ,139, and 9 in year 2003, 2004, and 2005 respectively. The others like one-way, two-way (divided with solid lines road marking), and two way (divided with broken line road marking) have average accident rates as shown Figure **20**. Thus, the investigation assured that the were dramatic accident reduction in all road lanes from year 2003 to 2005, except for double carriageway (with median) which shows two to three times of the accident frequency. Figure 20 illustrates graphical presentation of RTAs by road lanes.



	One way	Undivided two-way	Double carriageway(with median)	Two-way(divided with solidlines road marking)	Two-way(divided with brkoken line road marking)
2003	86	162	519	110	39
2004	37	139	1063	5	4
2005	5	9	1542	2	1

Figure 20: RTAs by Road Lane

4.1.12. RTAs By Road Character in Akaki-Kaliti Sub-City on Major Roads

Road characters have significant impact in determining the level of accident extents in a given area. Accordingly, Table **4.20** below shows the presence of adequate difference in various road character of the sub city, i.e., highest accidents were recorded in straight and level road character in the Sub-City with numbers of 778, 1221, and 1553 in 2003, 2004 and 2005 respectively. Besides, except in 2003, all the subject road characteristics did not practice significant accident in the sub-city.

Table 4.20: RTAs by Road Character

Road character	Number of road accidents			
	2003	2004	2005	2003-2005
Straight and level	778(85%)	1221(98%)	1553(99.6%)	3552(95%)
Straight and grade	69	7	1	77
Straight with up and down	16	4	0	20
Curve and level	18	5	0	23
Curve and grade	0	0	0	0
Up hill	6	4	1	11
Down hill	27	7	4	38
Unidentified (others)	2	0	0	2
Total	916	1248	1559	3723

4.1.13. RTAs by Vehicle Type in Akaki-Kaliti Sub-City Major Roads

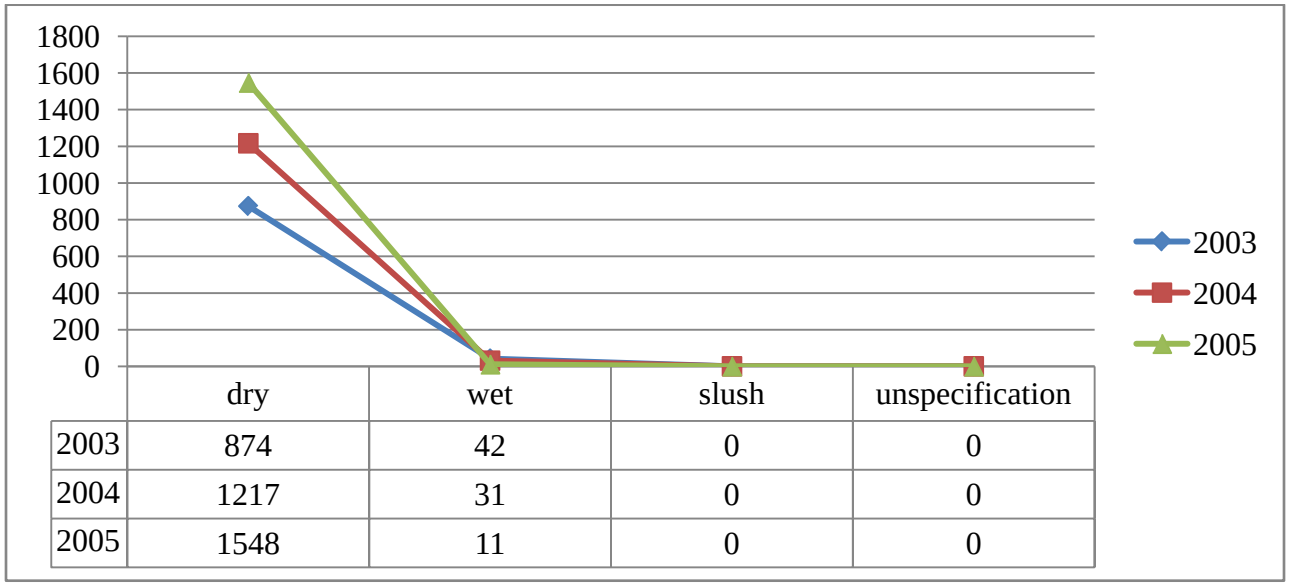
Table **4.21** shows the accidents occurred by different vehicle types; bicycle, motor bicycle, automobile, station wagon, pick up <=10 quintal, truck 11-40 quintal, truck 41-100 quintal, truck with trailer, liquid cargo , taxi, minibus up to 12 seats, bus 13-45 seats, bus>46 seats, earth moving , earth moving with trailer, cart, train, others and unknown. As the analysis result confirms in 2003, most accidents were caused by Automobile, truck 11-40 quintal, truck 41-100 quintal, truck with trailer, pick up <=10 quintal, minibus up to 12 seats, and bus 13-45 seats with accident rates of 178, 174, 120, 98, 75,74, and 70 respectively. However, the accidents frequencies for the first two vehicle types were almost more than double. In 2004, also truck 11-40 quintal, automobile, minibus up to 12 seats, truck with trailer , and pick up <=10 quintal caused most frequent accidents as compared to the other vehicle types (see Table **4.21**). In 2005, the total rate of accidents tremendously increased. Besides the most frequently causing RTAs, the chi-square test conformed that based on the vehicle category below, vehicles like truck with trailer, truck 41-100 quintal, truck 11-40 quintal overwhelmingly caused high accidents at p-value=0.000 ≤ 0.05, as shown in Table **B-60**, Appendix II.

Table 4.21: Accident by Vehicle Type

Vehicle Type (transport mode)	2003-2005 Year 2003	2004	2005	Total 2003-2005
Bicycle	4	7	1	12
Motor bicycle		10		10
Automobile	178	188	248	614
Station wagon	20	78	65	163
Pick up <=10 quintal	75	101	169	345
Truck 11-40 quintal	174	246	242	662
Truck 41-100 quintal	120	154	201	475
Truck with trailer	98	137	211	446
Liquid Cargo	16	23	35	74
Taxi	27	12	198	237
Minibus up to 12 seats	74	156	12	242
Bus 13-45 seats	70	66	80	216
Bus>46 seats	19	32	52	103
Earth moving	3	6	10	19
Earth moving with trailer				0
Cart	18	11		29
Train			0	0
Others			3	3
unknown	20	21	24	65
Total	916	1248	1559	3723

4.1.14. RTAs by road way surface condition in Akaki-Kaliti Sub-City Major Roads

Road surface condition dry, wet, slush, and un-specified conditions were used to investigate the severity of RTAs accidents by road conditions in the sub city. Accordingly, as shown in Figure **21** it was revealed that about 874, 1217, and 1548 of the accidents occurred in 2003, 2004, and 2005 on dry road surface conditions; and nearly approaching a double accident rates from 2003 to 2005. Consequently, in wet road surface conditions, about 42, 31, and 11 accidents occurred in 2003, 2004, and 2005 respectively. In contrary, no accidents occurred in slush and unspecified road surface conditions. Hence, the analysis confirms that almost all of the RTAs happened in dry road surface conditions (see Table **4.22**). Since p-value=0.000 ≤ 0.05, we shall reject the null hypothesis with Chi-square=4594.456>11.070=critical Chi-Square value.



	dry	wet	slush	unspecification
2003	874	42	0	0
2004	1217	31	0	0
2005	1548	11	0	0

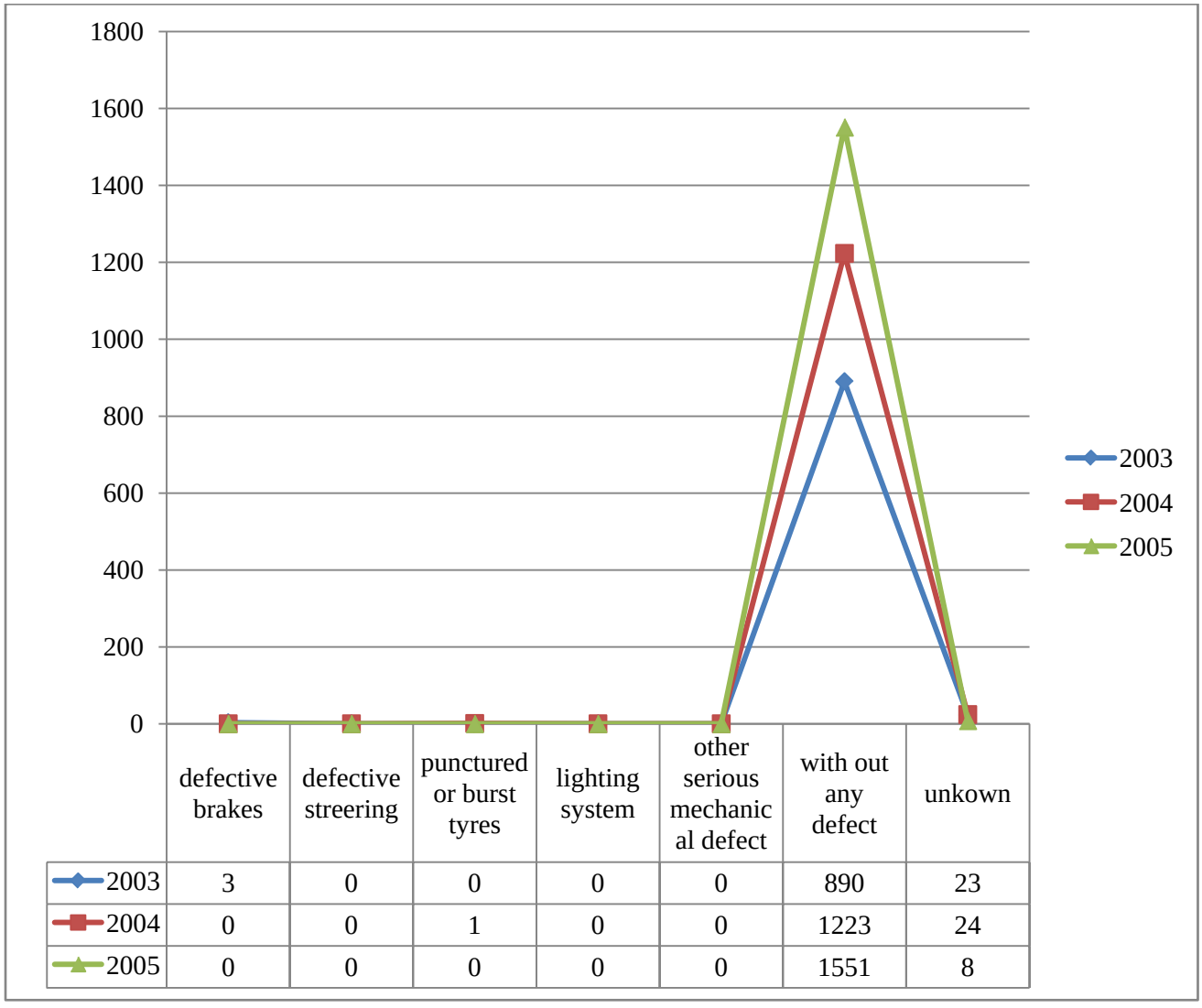
Figure 21: RTAS by roadway surface condition in Akaki-Kaliti Sub-City

Table 4.22: Calculation of Chi-Square under dry and wet road surface condition 2003-2005 at the Akaki-Kaliti

surface condition	Observed frequency	Expected frequency	d.f.	Critical χ^2	Calculated χ^2
dry	3639	2784.8	1	3.841	1048.199
wet	74	928.3			
Total	3713				
			Sig.	0.05	.000

4.1.15. RTAs by type of vehicle defect in Akaki-Kaliti Sub-City Major Roads

To investigate the level of RTAs occurred by vehicle defect, indicators were classified in respect of: defective brakes, defective steering, punctured or burst tyres, lighting systems, other serious mechanical defect, without any defect and unknown. From the mentioned vehicle defects, nearly all the accidents occurred vehicle with no present vehicle defects i.e., 890, 1223, and 1551 in 2003, 2004, and 2005 respectively. The remaining vehicle defects almost caused insignificant level of road traffic accidents in the Sub-City except with the unknown vehicle defects, which have lower accident rates (see Figure **22**).

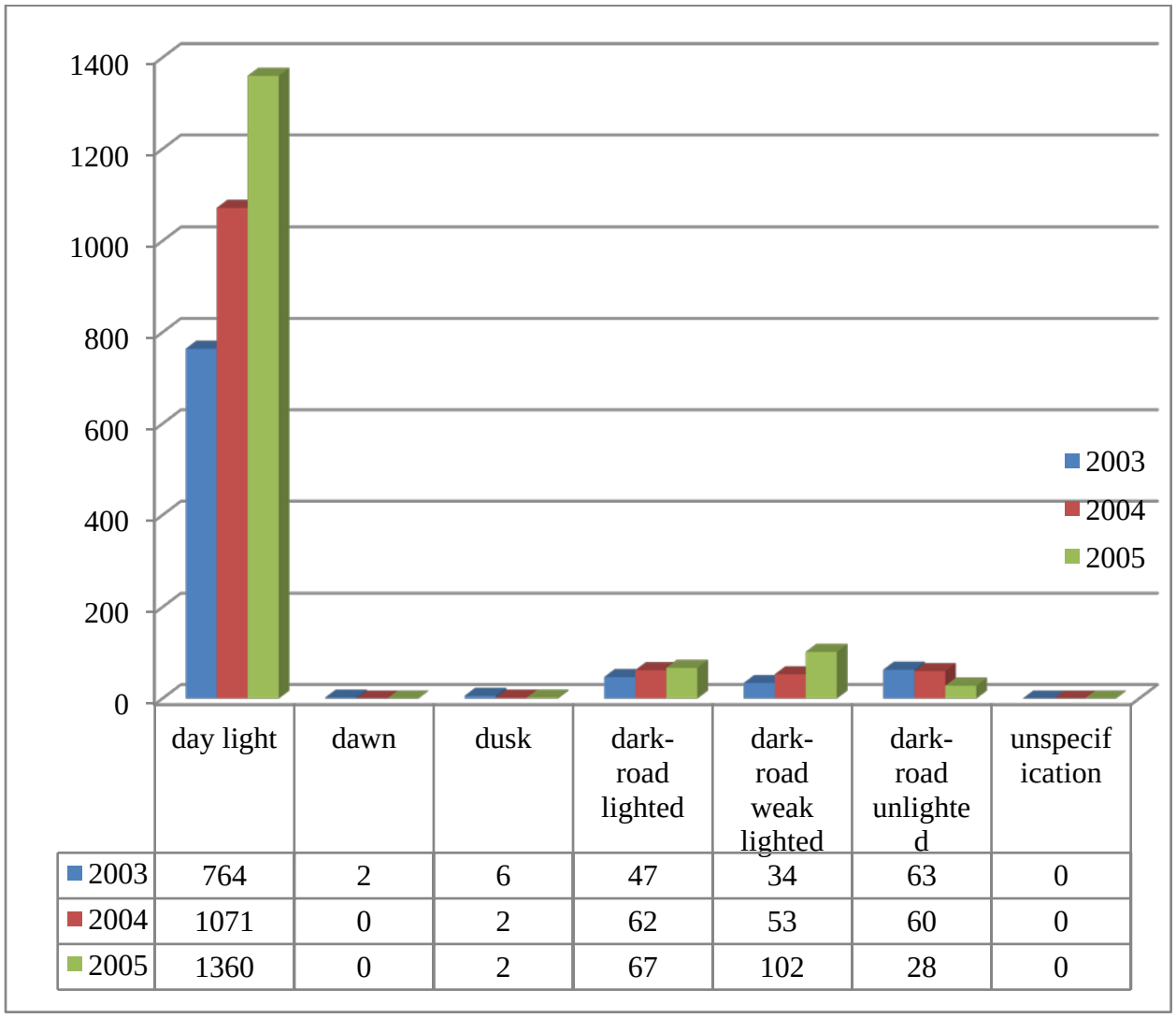


	defective brakes	defective streering	punctured or burst tyres	lighting system	other serious mechanical defect	with out any defect	unkown
2003	3	0	0	0	0	890	23
2004	0	0	1	0	0	1223	24
2005	0	0	0	0	0	1551	8

Figure 22: RTAS by type of vehicle defect in a Sub-City

4.1.16. RTAs by light condition in Akaki-Kaliti Sub-City Major Roads

Even though the existence of light is very important for the reduction of RTAs significantly, the analysis shows that almost all the RTAs, i.e. about 764, 1071, and 1360 accidents occurred during the day light in 2003, 2004, and 2005 respectively. The accidents in day light also showed significant growth from year to year in the Sub-City. Moreover, as compared to day light, medium accidents were reported in dark road lighted, dark road weak lighted and dark road unlighted conditions in the Sub-City from 2003 to 2005. Accidents those happened in dawn and dusk were relatively very low (see Figure **23** for the details).



	day light	dawn	dusk	dark-road lighted	dark-road weak lighted	dark-road unlighted	unspecification
2003	764	2	6	47	34	63	0
2004	1071	0	2	62	53	60	0
2005	1360	0	2	67	102	28	0

Figure 23: RTAs by light condition in a Sub-City

4.2. Spatial distribution of accidents in spot areas in Akaki-Kaliti Sub-City Major Roads

The aim of this study was to clearly identify the location of major road traffic accidents, black spot areas, and then to rank the sites and suggest engineering solutions (Black spot treatment). To minimize potential crashes, initially locations and segments of road traffic accident data were identified to ease the computation of black spot areas. Table **4.23** shows that in 2003, all fatalities range between 0 and 4. Highest accidents with value of 4 were recorded at Akaki Kela and Tirunesh Beijing Hospital (Near the Bridge). Regarding medium fatalities, 2-3 were recorded at Customs Office Entrance, Agricultural Marketing Entrance, Saris Abo Roundabout, and Prison Office Entrance (Crown Hotel) areas. From these, only 3 fatal reports were registered at Customs Office Entrance, and the remaining areas had a value of 2. The serious injuries highest above 10 occurred in Saris Abo Roundabout, Customs Office Entrance, Kaliti Roundabout, Cheralia Biscuit Factory, Kidinamihiret Church (Selam Buldg), Tirunesh Beijing Hospital (Near the Bridge) with numbers of 15, 13, 14, 13, and 11resspectively. Medium number of accidents, i.e. between 5-10 occurred at Korki (Medroc) Entrance, Akaki Market, and Akaki Kela with value of 8, 7, and 9 respectively.

Spatial areas that have less serious injuries between 0-4 were happened at Addis Tier (3), Agricultural Marketing Entrance (4), Kaliti Roundabout (2), Kaliti Driving Testing Center (1), Water Development (0), Prison Office Entrance (3), Kaliti St.Gebreail Church (3), and Drartu School Entrance (4)

The 2003 slight injury report was classified in two groups, i.e., with value of 0-5 and 6-10. Accordingly, areas like Addis Tier, Agricultural Marketing Entrance, Kaliti Roundabout, Kaliti Driving Testing Center, Water Development, Prison Office Entrance (Crown Hotel), Kaliti St.Gebreail Church, Total Kaliti Shoa Backery, Kidinamihiret Church(Selam Building) Akaki Kela, Tirunesh Beijing Hospital (Near the Bridge), Akaki Market, Kidinamihiret Church (Selam Building) have recorded light injuries between 1-5. In Contrary, 6-10 light injuries were recorded in Saris Abo Roundabout, Customs Office Entrance, Korki (Medroc) Entrance, and Cheralia Biscuit Factory. Furthermore, the property damage in 2003 was reported with minimum

and maximum values of 3 and 78 at spots of Akaki Market and Korki (Medroc) Entrance respectively (see Table **4.23**).

In 2004, no fatal accidents were reported at the Agricultural Marketing Entrance, Korki (Medroc) Entrance, Kaliti Driving Testing Center, and Kaliti Roundabout. But, areas like Kaliti St.Gebreail Church and Kidinamihiret Church (Selam Building) Showed tremendous fatal records as compared to 2003. Moreover, in the same year, reports showed comparably no significant increments in serious and light injuries except property damages. That means, the property damages significantly increased when compared with 2003 in the Sub-City.

In 2005, all causalities experienced certain growth (see Table **4.23**). For example, acute fatal accidents were exhibited at Agricultural Marketing Entrance, Total Kaliti Shoa Bakery, Kidinamihiret Church (Selam Building) and Derartu School Entrance. Serious and light injuries and property damages showed increment in areas of Agricultural Marketing Entrance, Saris Abo Roundabout, Water Development, Korki (Medroc) Entrance, Prison Office Entrance (Crown Hotel) Cheralia Biscuit Factory, and Total Kaliti Shoa Bakery.

Table 4.23: RTAs by Spatial Distribution with Accident Spot

No	Location/ Area	2003				2004				2005				Totol Casualty	Total Accident	
		Fatal	Serious injuries	Slight injuries	property damage (P.D.O)	Fatal	Serious	Slight	(P.D.O)	fatal	Serious	Slight	(P.D.O).		NO	%
1	Addis Tyre	1	4	3	14	1	3	2	12	3	1	1	12	19	57	1.8
2	Agricultural Marketing Entrance	2	4	2	11	0	2	0	15	2	4	2	20	18	64	2.0
3	Saris Abo Roundabout	2	15	9	45	3	13	7	90	4	24	6	134	83	352	11.2
4	Customs Office Entrance	3	13	6	45	3	15	3	56	3	15	4	46	65	212	6.7
5	Kaliti Roundabout	1	2	1	51	0	0	3	64	1	1	0	71	9	195	6.2
6	Kaliti Driving Testing Center	1	1	1	39	0	2	2	57	0	1	0	51	8	155	4.9
7	Water Development	1	0	3	18	1	4	3	35	2	3	2	60	19	132	4.2
8	Korki (Medroc) Entrance	1	8	11	78	0	10	4	93	2	9	5	145	50	366	11.6
9	Prison Office Entrance(Crown Hotel)	2	3	1	24	2	4	0	25	1	9	1	81	23	153	4.9
10	Kaliti St.Gebreail Church	1	3	5	34	5	4	1	53	0	5	3	75	27	189	6.0

No	Location/ Area	2003				2004				2005				Totol Casualty	Total Accident	
		Fatal	Serious injuries	Slight injuries	property damage (P.D.O)	Fatal	Serious	Slight	(P.D.O)	fatal	Serious	Slight	(P.D.O).		NO	%
11	Cheralia Biscuit Factory	0	14	10	51	2	18	5	63	0	15	7	85	71	270	8.6
12	Total Kaliti Shoa Bakery	1	6	3	41	2	13	4	94	4	5	7	119	45	299	9.5
13	Kidinamihiret Church(Selam Building)	0	13	4	35	6	4	2	31	3	9	4	36	45	147	4.7
14	Derartu School Entrance	1	4	6	12	3	9	2	32	3	11	4	52	43	139	4.4
15	Tirunesh Beijing Hospital(Near the Bridge)	4	11	5	42	4	12	7	25	5	15	8	49	71	187	5.9
16	Akaki Market	0	7	5	3	1	6	7	4	0	9	2	8	37	52	1.7
17	Akaki Kela	4	9	3	19	2	13	2	46	3	12	6	55	54	174	5.5
	Total	25	117	78	562	35	132	54	795	36	148	62	1099	687	3143	100

Generally, the summary report in figure **24** showed that, at the identified spot sections 2003-2005 highest accidents were exhibited at Cheralia Biscuit Factory,Total Kaliti Shoa Bakery ,Cheralia Biscuit Factory, and Total (Kaliti Shoa Bakery) areas with value of 366, 352,299, and 270 respectively. Whereas, between the same years, comparably low aggregated road traffic accidents were reported at Akaki Market, Addis Tyre and Agricultural Marketing Entrance with values of 52, 57, and 64 respectively.

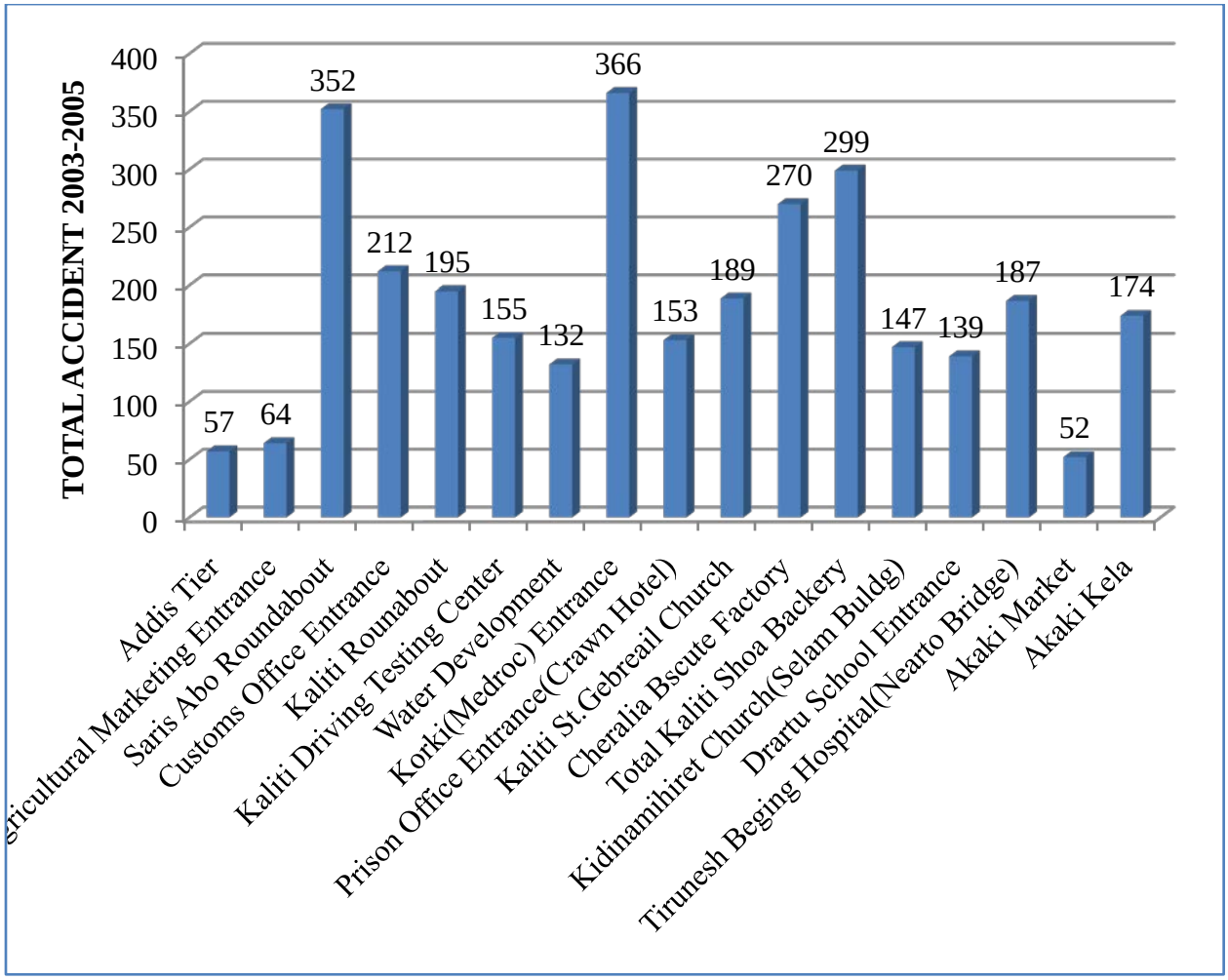


Figure 24: Summary of 2003-2005 casualties by location

4.3. Identification Of Black Spot Areas in Akaki-Kaliti Sub-City

A location whether link or node that experiences abnormal crash frequencies, rate is considered as an accident black spot. The method also incorporates exposure data such as traffic volume and length of the road section to determine if the critical accident rate at particular location is significantly higher than the average for each factor. Accordingly, accident rate calculation and black spot identification were undertaken by using the following analytical methods (**Quality control /critical crash rate factor /method).**

1. Determination of the location's during accident rate: it is determined on the basis of exposure data, such as traffic volume and length of the road section being considered at rate per million vehicle kilo meters ($\mathbf{U_f}$ **)** it is obtained from expression;

   For Junctions (or for accident spot):

   Uf = U x 106 / (AADT x 365 x n) injury accidents per million vehicles

   For Road sections:

   Uf = U x 106 / (AADT x 365 x n x L) injury accidents per million vehicle.-km

   U = number of reported injury accidents during the period n

   n = number of years

   L = section length (km

2. Determining the critical crash rate: critical crash rate factor method involved the following expression. The result provides the data for calculating critical accident rate (**Rc**) as shown in Equation (2). It is based on the assumptions that the crashes are approximated by Poisson Distribution

   Rc =**Ra**+ confidence level* $\sqrt{\frac{\mathbf{Ra}}{\mathbf{MEV}}+\frac{\mathbf{1}}{\mathbf{2*MEV}}}$ 2

   Rc = Critical Accident Rate (accidents per million vehicles or accidents per million vehicle-km)

   Ra= average crash rate

   MEV= Millions vehicle(km) during the analysis period

$$\mathbf{MEV} = \frac{\mathbf{ADT} * \mathbf{365} * \mathbf{n}}{\mathbf{1000000}}$$

n=Number of years

Ra = Average Accident Rate (accidents per million vehicles or million vehicle-km)

For Road sections

$$\mathbf{Rc} = (\mathbf{Average\ Crash\ Rate}) + \left((K) \sqrt{\frac{\text{Average Crash Rate}}{\frac{365 \times \mathrm{Y} \times [\mathbf{AADT}] \times [\mathbf{L}]}{1{,}000{,}000}}} \right) \left(\frac{\mathbf{1}}{\frac{\mathbf{2[365 \times Y \times (AADT) \times (L)]}}{\mathbf{1,000,000}}} \right)$$

For Junctions

$$\mathbf{Rc} = (\mathbf{Average\ Crash\ Rate}) + \left((\boldsymbol{K}) \sqrt{\frac{\mathbf{Average\ Crash\ Rate}}{\frac{\mathbf{365 \times Y \times [AADT]}}{\mathbf{1,000,000}}}} \right) \left(\frac{\mathbf{1}}{\frac{\mathbf{2[365 \times \boldsymbol{Y} \times (\boldsymbol{AADT})]}}{\mathbf{1,000,000}}} \right)$$

Where,

AADT = Average annual daily traffic for the spot (for an intersection, the sum of the volumes on all approaches).

Y = Number of years being analyzed

L = Length of the segment in kilometer (for intersection L is 1).

k=confidence level (95% confidence, k=1.645)

3. Compare the location's crash rate with the critical crash rate. If the crash rate exceeds the critical crash rate, classify the location as an accident Black Spot.

RANKING OF SITES

For prioritizing those black spots, the ratios of accident costs by degree of severity were established by TRL (2); the weight given for fatal accident is 5, for serious injury is 3, for light injury and property damage are 2 and 1 respectively.

$$\mathbf{P} = \frac{\mathbf{1} * \boldsymbol{w} + \mathbf{2} * \boldsymbol{X} + \mathbf{3} * \boldsymbol{Y} + \mathbf{5}\boldsymbol{Z}}{\boldsymbol{D}}$$

Where:

P=Priority value;

w= Total number of property damages;

X= Total number of light injuries;

Y = Total number of serious injury;

Z = Total number of deadly injuries;

D = Total number of distance of the black spot section in kilometer.

Thus, by using the formulas above for the identification of black spot segment, black spot sections, and ranking black spots, out of the Sub City accident spot ar**e**as (see Table **4.24**) and for detail calculation of black spot identification (see Table **4.25**). The following accident spot areas and segments were selected as **Black spots** from the Sub City roads (see Table **4.25** and Table **4.26** for details) with their rank orders ranging for the spot section between 1 to 7. They are, Saris Abo Roundabout, Tirunesh Beijing Hospital (Near the Bridge), Customs Office Entrance, Total (Kaliti Shoa Bakery), Korki (Medroc) Entrance, Cheralia Biscuit Factory, Akaki Kela (Near UNISA), which ranked from 1-7 respectively.

Table 4.24: accident spot areas in Akaki-Kaliti Sub-City roads

No	BLACK SPOT SECTIONS	2003				2004				2005				CASUALTY	TOTAL ACCIDENT	
		fatal	Serious injuries	Slight injuries	property damage	fatal	serious	slight	property damage	fatal	serious	slight	property damage	NO	NO	%
1	ADDIS TYRE	1	4	3	14	1	3	2	12	3	1	1	12	19	57	1.8
2	AGRICULTURAL MARKETING ENTRANCE	2	4	2	11	0	2	0	15	2	4	2	20	18	64	2.0
3	SARIS ABO ROUNDABOUT	2	15	9	45	3	13	7	90	4	24	6	134	83	352	11.2
4	CUSTOMS OFFICE ENTRANCE	3	13	6	45	3	15	3	56	3	15	4	46	65	212	6.7
5	KALITI ROUNDABOUT	1	2	1	51	0	0	3	64	1	1	0	71	9	195	6.2
6	KALITI DRIVING TESTING CENTER	1	1	1	39	0	2	2	57	0	1	0	51	8	155	4.9
7	WATER DEVELOPMENT	1	0	3	18	1	4	3	35	2	3	2	60	19	132	4.2
8	KORKI(MEDROC) ENTRANCE	1	8	11	78	0	10	4	93	2	9	5	145	50	366	11.6
9	PRISON OFFICE ENTRANCE(CROWN HOTEL)	2	3	1	24	2	4	0	25	1	9	1	81	23	153	4.9

10	KALITI St.GEBREAIL CHURCH	1	3	5	34	5	4	1	53	0	5	3	75	27	189	6.0
11	CHERALIA BISCUIT FACTORY	0	14	10	51	2	18	5	63	0	15	7	85	71	270	8.6
12	TOTAL(KALI TI SHOA BACKER	1	6	3	41	2	13	4	94	4	5	7	119	45	299	9.5
13	KIDINAMIHI RET CHURCH(SE LAM Building)	0	13	4	35	6	4	2	31	3	9	4	36	45	147	4.7
14	DRARTU SCHOOL ENTRANCE	1	4	6	12	3	9	2	32	3	11	4	52	43	139	4.4
15	TIRUNESH BEIJING HOSPITAL(NE ARTHE BRIDGE)	4	11	5	42	4	12	7	25	5	15	8	49	71	187	5.9
16	AKAKI MARKET	0	7	5	3	1	6	7	4	0	9	2	8	37	52	1.7
17	AKAKI KELA(NEAR UNISA)	4	9	3	19	2	13	2	46	3	12	6	55	54	174	5.5

Table 4.25: Calculating of accident black spot identification areas in Akaki-Kalit Sub-City roads

No	Type	Sections	Kilo meter	No of accident in three years (2003-2005)	No of accident per KM per years	ADT	(million entering vehicle) Mv	(Million entering vehicles kilometers) Mvk	Average crash rate per Mvk of segments	Accident rate at each section	Accident rate at each segment	Critical crash rate for each section	Critical crash rate for each segments	Critical
1	SEGMENT	Kaliti Rounabout-Total	6.1	1564	86	53263	58	356	3.37		4.40		3.5	over
	SPOT	**Kaliti Roundabout**	0	195		54865	60		3.90	3.25		4.44		**under**
	SPOT	**Kaliti Driving Testing Center**	0.1	155		53263	58		3.90	2.66		4.45		**under**
	SPOT	**Water Development**	0.1	132		53263	58		3.90	2.26		4.45		**under**
	SPOT	**Korki(Medroc) entrance**	0.2	366		53263	58		3.90	6.28		4.45		**over**
	SPOT	**Prison Office entrance(Crown Hotel)**	0.1	153		53263	58		3.90	2.62		4.45		**under**
	SPOT	**Kaliti St.Gebreail Church**	0.1	189		53263	58		3.90	3.24		4.45		**under**

	SPOT	**Cheralia Biscuit Factory**	0.1	270		53263	58		3.90	4.63		4.45		**over**
	SPOT	**Total(Kaliti Shoa Bakery**	0.2	299		53263	58		3.90	5.13		4.45		**over**
2	**SEGMENT**	**Total-Kidinamihiret -Kela**	5.2	508	33	30075	33	171	3.37		2.97		3.6	**under**
	spot	**Kidinamihiret Church(Selam building)**	0.25	147		30075	33		3.90	4.46		4.59		**under**
	spot	**Tirunesh Beijing Hospital(near the Bridge)**	0.2	187		30075	33		3.90	5.68		4.59		**over**
	spot	**Akaki Kela(near UNISA)**	0.2	174		30075	33		3.90	5.28		4.59		**over**
3	**SEGMENT**	**Total-Derartu-Akaki Market-Kela-Tulu Dmtu**	4.8	191	13	25147	28	132	3.37	6.94	1.45		3.6	**under**
	spot	**Derartu School entrance**	0.2	139		25147	28		3.90	4.05		4.65		**under**
	spot	**Akaki Market**	**0.1**	**52**		20147	22		3.90	2.36		4.72		**under**

4	**SEGMENT**	**Belay ab-Kaliti Roundabout**	2.5	333	91	40835	45	112	**3.37**		2.98		3.7	**under**
	spot	**Addis Tyre**	0.2	57		40835	45		3.90	1.27		4.51		**under**
	spot	**Agricultural Marketing entrance**	0.3	64		40835	45		3.90	1.43		4.51		**under**
	spot	**Saris Abo Roundabout**	0	352		50835	56		3.90	6.32		4.46		**over**
	spot	**Customs Office entrance**	0.2	212		40835	45		3.90	4.74		4.51		**over**

Table 4.26: Black spot segment and sections on Akaki-kaliti Sub-City

Ranking of accident spots helps to assess which place is to be given immediate attention. Quality control is the method used for identification of black spot segments and spots in Aaki-Kaliti Sub-City roads so that the accident frequencies of all the spots over the 3-year period are calculated. The logic of this method is that a location is considered to be a black spot if its safety parameter shows higher values (location's crash rate) than the critical value, and then ranking of accident spots based on calculated severity established by TRL (2) value are ranked.

BLACK SPOT SEGMENT

No	BLACK SPOT SEGMENT	2003-2005				PRIORITIZATION						Rank
		Fatal	Serious	Slight	Property damage	D (KM)	Z	Y	X	W	P	
1	KALITI ROUNDABOUT-TOTAL	28	137	78	1321	6.1	0	411	156	1321	332	1

BLACK SPOT SECTIONS

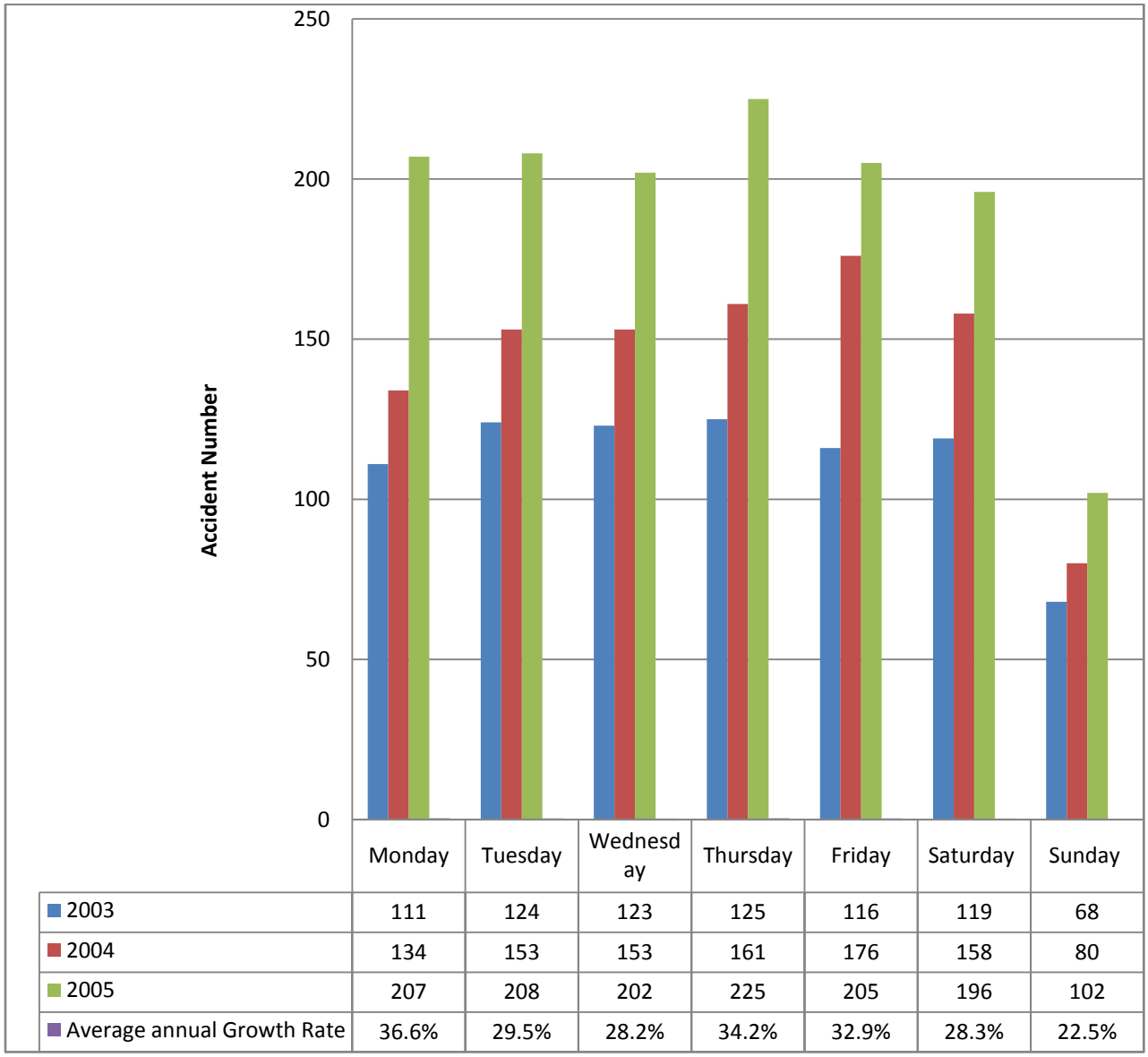
No	BLACK SPOT SECTIONS	2003-2005				PRIORITIZATION					Rank
		Fatal	Serious	Slight	Property damage	Z	Y	X	W	P	
1	SARIS ABO ROUNDABOUT	9	52	22	269	45	156	44	269	83088720	1
2	CUSTOMS OFFICE ENTRANCE	9	43	13	147	45	129	26	147	22186710	3
3	KORKI (MEDROC) ENTRANCE	3	27	20	316	15	81	40	316	15357600	5
4	CHERALIA BISCUIT FACTORY	2	47	22	199	10	141	44	199	12345960	6
5	TOTAL (KALITI SHOA BAKERY)	7	24	14	254	35	72	28	254	17922240	4
6	TIRUNESH BEIJING HOSPITAL(NEAR THE BRIDGE)	13	38	20	116	65	114	40	116	34382400	2
7	AKAKI KELA (NEAR UNISA)	9	34	11	120	45	102	22	120	12117600	7

4.4. Temporal analysis of selected spot areas

Temporal analysis of road traffic accidents has paramount importance to determine when the accidents reached peak time and in which day the accidents were very severe. Hence, in this part of the current study, the researcher discusses road traffic accident extent in days of the week and time of a day.

4.4.1. Traffic accidents by Day of a week in selected black spot Segment and spot areas

Figure **25** below demonstrate that about 111, 124, 123, 125, 116, 119, and 68 road traffic accidents occurred on Monday, Tuesday, Wednesday, Thursday, Friday, Saturday, and Sunday respectively in 2003, i.e., and this confirms the presence of slight accident difference by day of a week in 2003, except Sunday. Because, on Sunday the number of reported road traffic accidents was reduced by nearly half from Tuesday, which have severe accidents. Moreover in 2004, the number of road traffic accidents increased from 2003 with low accident variation from Monday to Saturday. Like the data in 2003, Sunday had very small road traffic accidents. This may be because of low movements of vehicles, passengers, and pedestrians on weekends in the selected black segment & spot areas. Similarly, the risk of road traffic accidents in 2005 remarkably increased as compared to 2003 and 2004. That is, the road traffic accidents were nearly doubled in all day of the week in 2005 from 2003, and had accidents of 207, 208, 202 ,225, 205, 196, and 102 on Monday, Tuesday, Wednesday, Thursday, Friday, Saturday, and Sunday respectively in 2005.



	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
2003	111	124	123	125	116	119	68
2004	134	153	153	161	176	158	80
2005	207	208	202	225	205	196	102
Average annual Growth Rate	36.6%	29.5%	28.2%	34.2%	32.9%	28.3%	22.5%

Figure 25: Number of Accident 2003-2005 by Day of the Week

Generally, the trends of accidents from 2003 to 2005 have shown acute increments despite the Government's effort to undertake remedial measures like road traffic accidents awareness creation activities through mass media for the community, students, drivers, and Government trying to upgrade the quality of drivers by adopting new licensing systems for different types of vehicles. Besides, much effort have also been undertaken in increasing the road networks in the City (see Figure **26**).

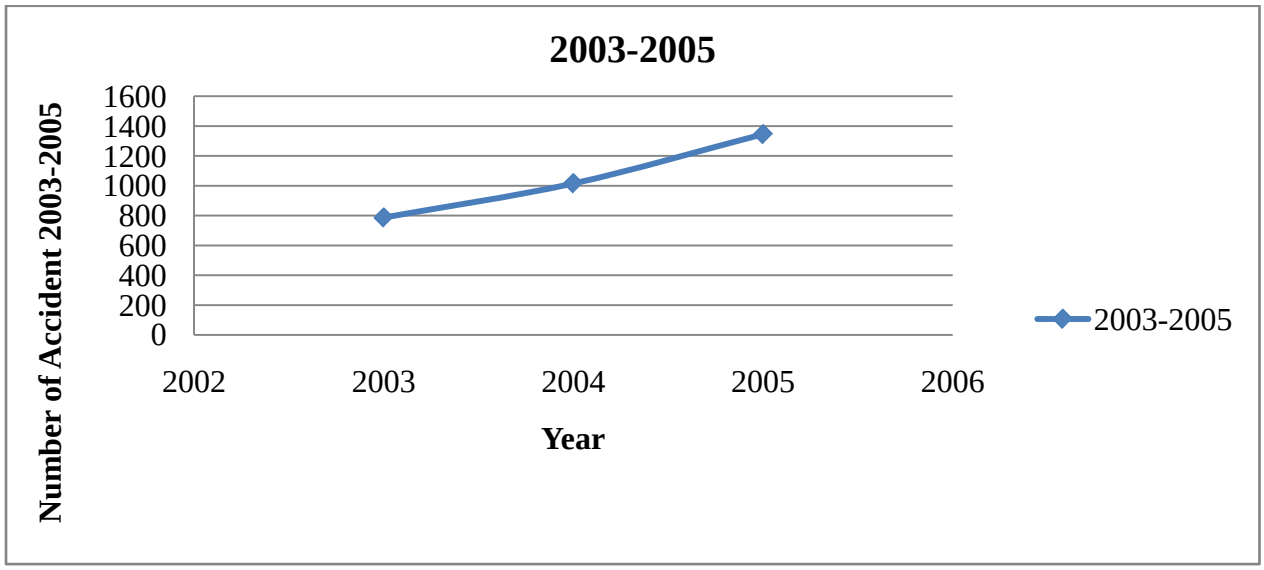
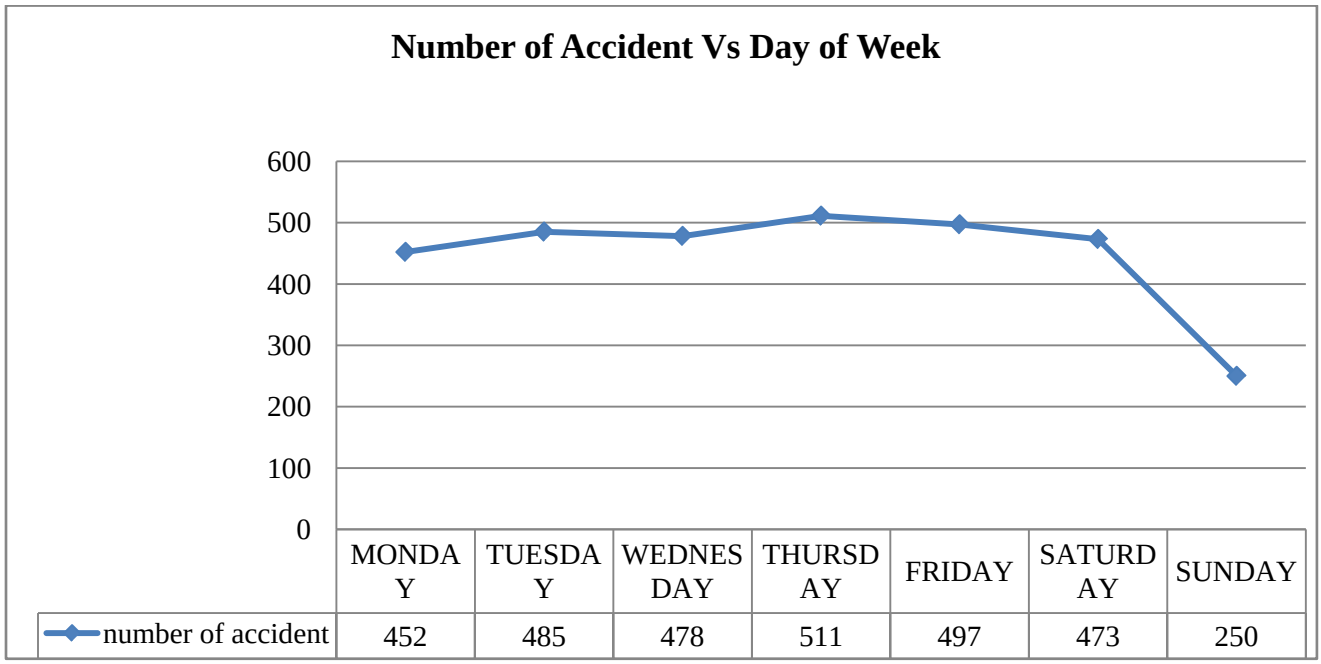


Figure 26: Comparison of road traffic accidents (2003-2005)

Whereas, the summary report of data collected from the Akaki-Kaliti Traffic Police showed that, road traffic accidents reached maximum on Thursday followed by Friday and Wednesday during the weeks between 2003 and 2005. The accident started declining on Saturday and reached minimum on Sunday (see Figure **27**).



	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY	SUNDAY
number of accident	452	485	478	511	497	473	250

Figure 27: Summary of road traffic accidents

4.4.2. Traffic accidents by hour of the day (2003-2005) in the selected areas

Traffic accident rate varies upon the nature of hour of the day, and mostly road traffic accidents occurred when the passenger movements from place to place reached maximum levels. In this regard, the study reveals that in 2003, highest road traffic accidents were reported between 11:00-12:00 with 92 accidents followed by 10:00-11:00, and 12:00-13:00 with the total number of accident of 65 and 62 respectively. While the lowest number of traffic occurred during 2:00-4:00 (see Figure **28** and Table **A-30**).

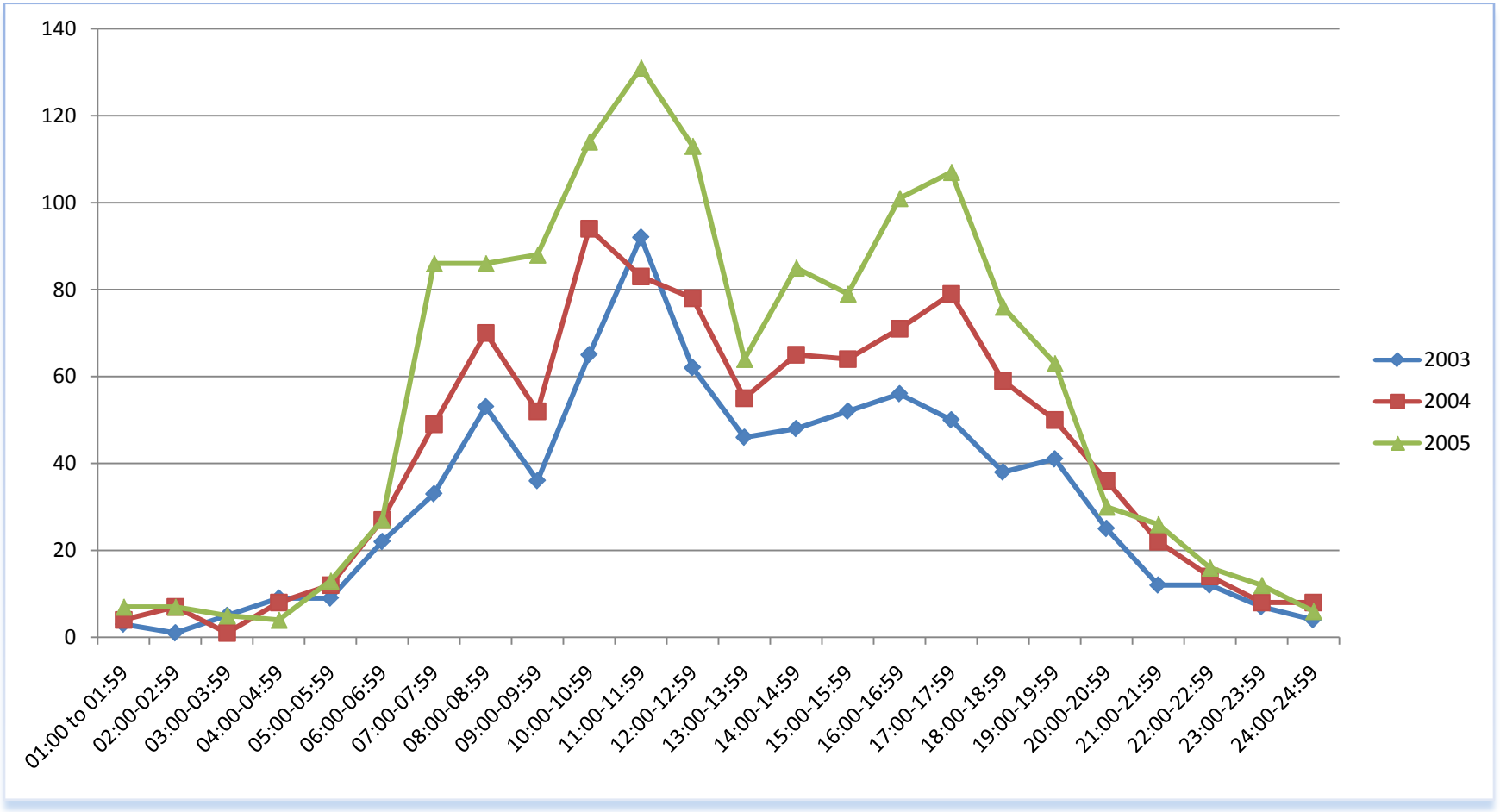


Figure 28: Graphical comparison crashes per hour of a day (2003-2005) in selected area

Furthermore, in 2004, in the selected areas, highest number of crashes happened at the same time with 2003 with a little time /duration change, i.e., 10:00-11:00 with 94-accidents followed by 11:00-12:00 and 12:00-13:00 with the total accidents of 83 and 78 respectively. Relatively, the lowest number of accidents were reported in 03:00-04:00, 01:00-02:00, 2:00-3.00, 24:00-25:00, 04:00-054:00, 23:00-24:00 ,and 24:00-25:00 with accident rates of 1, 4, 7, 8,8, and 8 in 2004 respectively (see Table **4.27**). The same trends appeared in 2005 in selected areas with peak accident rates during 11:00-12:00, 10:00-11:00 and 12:00-13:00 with accidents number of 131, 114, and 113 respectively while the lowest number of accidents happened in plateau hours of 23:00-24:00, 24:00-01:00, 01:00-02:00, 02:00-03:00, 03:00-04:00 and 04:00-05:00.

Table 4.27: Total number of crashes in 2003, 2004, and 2005

Crash hour	Total Number Of Crash	Selected black spot areas			Classification
		2003	2004	2005	
01:00-01:59	14	3	4	7	Minimum Crashes/ plateau hours
02:00-02:59	15	1	7	7	
03:00-03:59	11	5	1	5	
04:00-04:59	21	9	8	4	
05:00-05:59	34	9	12	13	Relatively Intermediate
06:00-06:59	76	22	27	27	
07:00-07:59	168	33	49	86	
08:00-08:59	209	53	70	86	
09:00-09:59	176	36	52	88	
10:00-10:59	273	65	94	114	Maximum crash hours/Peak hours
11:00-11:59	306	92	83	131	
12:00-12:59	253	62	78	113	
13:00-13:59	165	46	55	64	Relatively Intermediate
14:00-14:59	198	48	65	85	
15:00-15:59	195	52	64	79	
16:00-16:59	228	56	71	101	
17:00-17:59	236	50	79	107	
18:00-18:59	173	38	59	76	
19:00-19:59	154	41	50	63	
20:00-20:59	91	25	36	30	
21:00-21:59	60	12	22	26	
22:00-22:59	42	12	14	16	
23:00-23:59	27	7	8	12	
24:00-24:59	18	4	8	6	Minimum Crashes/ plateau hours
Total	3143	781	1016	1346	

Besides the above analysis, the summary of the descriptive statistics for number of crashes in 2003, 2004, and 2005 in hour of a day has shown large difference among their calculated mean value of crash rate. Accordingly, table **4.28** illustrates the mean number of accidents in 2003, 2004, and 2005 as 32.5, 42.3, and 56.1 per hour per year respectively. That is, on average there were 33, 42, and 56 accident per hour during 2003-2005. Moreover, crash statistics confirmed tremendous increment from 2003-2005 in the selected Black spots of the Akaki-Kaliti Sub-City.

Consequently, to check whether there is statistically significant difference among the selected years or not, and hence paired t test was run since each comparable variable has continuous and scaled type. Accordingly, the paired t test result conform the presence of statistically significant mean difference among the three selected years in hour of a day. Meaning, the test showed the presence of statistically significant/severe crash difference/hour of a day at the probability level of (p=0.000). Accordingly, there were -9.79167, -23.54167, and -13.75000 crash mean differences between 2003 and 2004, 2003 – 2005, and 2004 - 2005 per hour in a day respectively (Table **4.28**).

Table 4.28: Paired Samples Statistics

	Mean	N	Std. Deviation	Std. Error Mean
crash2003	32.5417	24	24.54451	5.01013
crash2004	42.3333	24	29.86880	6.09694
crash2005	56.0833	24	42.72248	8.72069

Paired Samples Test

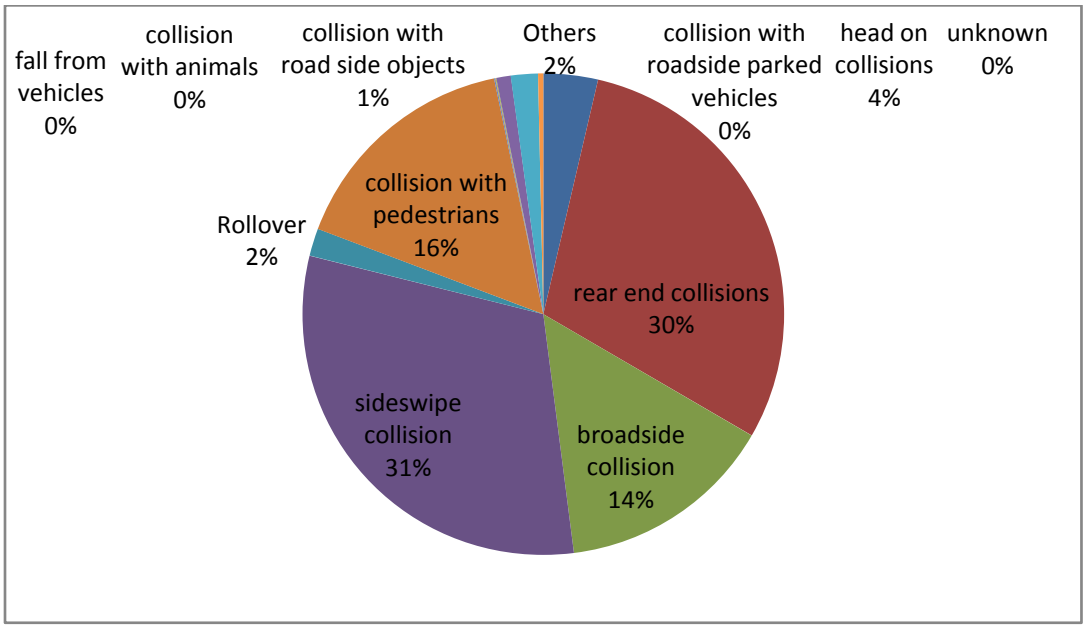
		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	crash2003 - crash2004	-9.79167	9.57796	1.95509	-13.83608	-5.74725	-5.008	23	.000
Pair 2	crash2003 - crash2005	-23.54167	20.67550	4.22037	-32.27217	-14.81117	-5.578	23	.000
Pair 3	crash2004 - crash2005	-13.75000	15.14926	3.09233	-20.14697	-7.35303	-4.446	23	.000

4.4.3. Collisions Types In Selected Black Spots

Collision types in this study include, head on collisions, rear end collisions, broadside collision, sideswipe collision, rollover, collision with pedestrians, collision with animals, fall from vehicles, collision with roadside parked vehicles, collision with road side objects, and collision with train. The collision types were computed within 2003-2005 in the selected black spot areas and showed significant difference among the types of collisions. Accordingly, from the totally 96 fatal accidents occurred in the selected spot areas, about 88 were collisions with pedestrians' and also the remaining collision types is not as such frequent fatal accidents. Whereas, the trends in serious accidents dramatically increased in all collision types except collision with animals, fall from vehicles, collision with roadside-parked vehicles, collision with roadside objects, and collision with trains. Especially, the collisions with pedestrians increased more than three times, and others collision types such as head-on collisions, rear-end collisions, broadside collision, and sideswipe collision overwhelmingly increased as compared to the fatal accidents in the identified Black spot areas. Similarly, the magnitude of slight accidents of head-on collisions, rear-end collisions, broadside collision, sideswipe collision, and collision with pedestrians showed a decreasing trend when compared with serious accidents, but still higher than fatal reports (see Table **4.29**). The extent of property damage collisions types have very dramatic effects; for instance, 919, 867, 428,103, and 46 property damages were recorded because of collision with sideswipe collision, rear-end collisions, broadside collision, head-on collisions, and Rollover respectively. In any way, this study confirms that the majority of fatal accidents were collision with the pedestrians though others also had a moderate impact, and also serious, slight and property damages occurred because of collision with sideswipe collision, rear-end collisions, broadside collision, head-on collisions and Rollover.

Table 4.29: Collisions Types in the Selected Black Spot Areas

No	COLLISIONS TYPE	2003-2005				2003	2004	2005	Total
		Fatal	Serious	Slight	Property damage				
1	Sideswipe collisions	0	29	23	919	193	272	506	971
2	Rear end collisions	2	44	20	867	217	306	410	933
3	Collision with pedestrians	88	291	121	1	162	158	181	501
4	Broadside collisions	0	15	15	428	103	161	194	458
5	Head on collisions	2	6	4	103	52	48	15	115
6	Rollover	1	8	3	46	21	18	19	58
7	Collision with road side objects	1	0	1	28	10	18	2	30
8	Collision with animals	1	0	0	1	0	2	0	2
9	Collision with roadside parked vehicles	0	0	0	2	0	1	1	2
10	Fall from vehicles	0	0	1	0	0	1	0	1
11	Collision with trains	0	0	0	3	0	0	0	0
12	Others	0	3	3	51	22	25	10	57
13	Unknown	1	1	3	6	2	6	3	11
14	Total	96	397	194	2455	782	1016	1344	3142



4.5. ENGINEERING SOLUTION MEASURES FOR BLACK SPOTS

4.5.1. SARIS ABO ROUNDABOUT

Site description: *Saris Abo roundabout,* which is also known as "**Abo** to" the local people, is located on the dense traffic areas where majority of heavy to medium tracks, local shops, and many schools were found. Moreover, due to the presence of "St. ABO "church in the area, many Christian followers visit the area frequently on foot, by taxis, and by their own vehicles besides the local communities' massive movement on the road. Thus, the area practiced the highest RTAs comparing with other Black spots identified. Consequently, the data indicate that 85% of the accident during 7 am-7 pm on every day form Sunday to Monday (10%-17% of the total accident). According to the collision type of the accidents, rear end collisions, sideswipe collision and collisions with pedestrians, this contains about 92% of the whole collision categories.

Field investigations;- Saris Abo roundabout is surrounded by many residential, commercial, administrative settlements, church, school and market areas with a significant number of heavy vehicles using the road, especially during early in the morning and late in the evening. Photographs of some field observations on the area which shows deficiencies of the rout contribution exposures for those type of collisions especially for pedestrian and vehicle conflicts are presented below.

- The walkway is not properly used by pedestrian, it becomes parts of shopping that force pedestrians to walk along the road, then Carriageways or the edge of carriageways are used as footways. It is common to observe pedestrian and vehicle conflicts (see Figure **29, 30**).
- Pedestrian crossing lines have faded out almost completely at all approaches, in the median also, absence of proper routine maintenance has been observed. The pedestrians' refuge island area are facing big pothole that could create potential safety problems while crossing. These conditions could lead to serious intersection accidents or collisions with pedestrians (see Figure **31**, **32**).
- There is high volume of on-street parking, and parked vehicles not safely parked inside the travelled lane and these conditions continue disturbing the smooth traffic movement, and they create serious problems for drivers and vulnerable road users'(see Figure **29**, **30,32**).
- High intensity of intercity freight and passenger vehicular traffic passes through the entire area.

- Absence of proper routine maintenance which caused vehicles to have sudden break or parked on the outer travelled lane which could lead to serious accidents has been observed(see Figure **32**)
- Along the pedestrian walkways, there have been many concrete blocks and improper wooden electric pole location, which were located at the center of the walkway on one side and which could create higher potential safety problems to the road users (pedestrians) (see Figure **32**).
- There is no roadside barrier used to separate roadways from pedestrian and to cause to lead the pedestrian to the correct way (see Figure **29, 30, 32**).
- Color of dress can help to avert many accidents under low light conditions. Whoever the student who crosses the road wears dark school uniform(see Figure **31**)

Figure 29. Saris Abo roundabout (Illegal obstruction of footway)

Figure 30.Photo. Illegal obstruction of footway.

Illegal obstruction of footway is a main contribution to accidents. As a result, there are conflicts between pedestrians and vehicles, and pedestrians are forced to use carriageways or the edge of carriageways as footways.

Figure 31.Photo. No zebra crossing (Lack of pedestrian crossing).

Because of absence of zebra crossing for pedestrians, it is common to see conflicts between pedestrians and vehicle, and pedestrians are forced to use the carriageways or the edge of carriageways as footways.

Figure 32.Photo. Carriageways and the edge of carriageways as footway.
They are used as footways, lack of routine maintenance, and lack of fence lead the pedestrian to unsafe crossing .There is lack of light pole in sidewalks.

Improvement needs: The treatment is designed to reduce the number and severity of crashes. Based on the identified the type of crash found from analysis of the data base and site inspection observed, the related countermeasures which have been successful in similar circumstances which are related to the type of crash found. Thus, easily implementable improvements are suggested for these black spots as follows.

- Zebra crossing should be provided and warning sign of pedestrian crossing should be placed at zebra crossing on both sides in order to minimizing the accident collision with pedestrians.
- Provide fence to lead the pedestrian to safe crossing and avoiding trading on the walkways so that it is easy to minimizing the accident collision with pedestrians.
- Traffic policy should be supplied with modern equipments and facilities to carry their tasks.
- To increase the visibility bright color of dress can help to avert many accidents under low light conditions, especially when trying to cross the road and while walking on the roads without footpath etc. Therefore, it is good to promote the use of bright color for School Uniforms so that the accident collision with pedestrians gets minimized.
- Responsible authority should enforce street shopping and neighbor stores not to sell or Place some goods on the sidewalks.

4.5.2. Tirunesh Beijing Hospital (Near The Bridge)

Site description and traffic data analysis: Tirunesh Beijing Hospital (Near the Akaki Bridge) is located near to the Akaki Bridge and Akaki market. The frequency of communities to the Market and to the hospital is very high and hence, the area practiced the high fatal, serious, slight and property damage accidents which exacerbates the rate of causalities and accidents of RTAs in the area. The collision types facing on the area are rear end collisions, head on collisions, broadside collision, rollover, sideswipe collision, and collisions with pedestrians. As can be seen from Table **B-62** Appendix II, collisions with pedestrians accounted for about 28 % during three-year period, which is the highest collision type facing on the area. With regard to time, the highest accident crash occurs at 6 AM -8 PM, which are 170 accidents from the 187 crash numbers. Furthermore, road users are not well aware of traffic rules and regulation in the city. In major area of the study road sections, carriageways or the edge of carriageways are used as footways. It is common to observe pedestrian and vehicle conflicts. Photographs of some field observations on the area, which shows deficiencies of the rout contribution exposures for those types of collisions especially for pedestrian and vehicle conflicts, are presented below.

Site inspection

- There was a complete absence of lane marking. The Absence of lane marking caused vehicle drivers to leave a particular travelled lane that creates confusion among motorists and to cause a serious accident of head on collisions. There is no route edge line marking throughout the observed route section, and drivers using inner lane might mistakenly hit the median edge due to the edge line missing and create accidents. There were complete absence of transverse markings of the route, and this condition could lead to serious intersection accidents for pedestrian and vehicle conflicts (see Figure **34, 35, 36**).
- There is no approach safety barrier (Lack of guard fencing) and road marking completely at the curve and approach of bridge (see Figure **33**).
- Absence of proper routine maintenance which caused vehicles to have sudden break or parked on the outer travelled lane which could lead to serious accidents has been observed (see Figure **35, 36, 37).**

- There is no pedestrian crossing provided .Pedestrians are susceptible for accidents. The route has faded markings, especially at the pedestrian crossing location, but the overall condition of road marking along the route was terrible (see Figure **34, 35, 36)**.
- Poor drainage systems and pond of water have been observed and these problems create high potential safety problems to vehicle drivers and vulnerable road users (see Figure **35, 36).**
- There is no pedestrian walkway provided. Carriageways and the edges of carriageways are used as footways. It is common to observe pedestrian and vehicle conflicts (see Figure **35, 36)**.

Figure 33.Photo. Lack of guard fencing, and there are branches of the trees inner side of road. The guard fencing used to prevent a vehicle from leaving the roadway and to reinforce the safe crossing point, and the branches of the tree limited sight distance due to branches of the trees.

Figure 34.Photo. Faded and invisible pedestrian crossing markings, complete absence of lane marking (edge line, median markings, transverse), and no pedestrian walkway

Figure 35.Photo. Poor drainage systems, pond of water at the Carriageway pedestrians trying to deal with the water obstacle fail to observe approaching vehicles, complete absence of lane markings (edge line, median, transverse markings) and vehicle height limit Warning sign not located at appropriate location ,beside this the sign is also worn out.

Figure 36.Photo. Pond of water at the Carriageway, complete absence of lane marking (edge line, median, and transverse markings), and lack of maintenance

Figure 37.Photo. Bridge damage by vehicles' (collision with roadside objects), lack of maintenance, and create high potential safety problems to vehicle drivers and vulnerable road users

Figure 38.Photo. Night driving condition at Akaki- kaliti, that is absent of streetlights, pedestrian crossing lighting, generally no accessories for all road users.

Improvement needs: The treatment is designed to reduce the number and severity of crashes. Based on the identified the type of crash found from analysis of the database and site inspection observed, the related countermeasures that have been successful in similar circumstances, which related to the type of crash found. So that easily implementable improvements are suggested for these black spots as follows.

- Walkway facilities should be provided on the overall route section in order to protect and separate pedestrian from moving vehicles. This will avoid or minimize the accident collision which is the highest collision type facing on the area with pedestrians.
- Warning sign of pedestrian crossing should be placed at zebra crossing on both sides in order to minimize the accident collision with pedestrians.
- Prohibit overtaking at the curve to minimize the rear end collisions and sideswipe collisions facing on the area. Installation of traffic controls like **DO NOT OVERTAKE**
- Zebra crossing should be marked with vertical signs and horizontal marking
- To separate the opposing streams of vehicles the median should be identified by road marking so as to minimize the head on collisions and sideswipe collisions facing on the area.
- Marking should be durable, visible by day and at night, skid resistant, and unambiguous. They give drivers clear information to guide them safely along the road and through any potential conflict points.
- Provide new guard fencing at the approach of the bridge , pedestrians may choose a time-saving and sometimes more hazardous crossing so that the new guard fencing controls must be required to reinforce the safe crossing point.
- On the time of high crash hour (6 am-8 pm), traffic police should be available in the area
- A pool of water and a hanging branch of tree on roadsides can cause accident; as such, obstructions will make the pedestrians /drivers to take sudden lateral (cross) movement and result in accidents. Hence, the obstruction on roadsides which cause a cross movement should be completely rectified timely.
- Footpath should be provided on service road at underpass location
- Trimming trees from inner side of road in order to improve the limited sight distance.

- Improve Visibility by Providing street lighting, pedestrian crossing lighting, accessories for all road users. Lighting is important to include at all pedestrian crossing locations for the comfort and safety of the road users. Lighting should be present at all marked crossing locations. Lighting provides cues to drivers to expect pedestrians earlier and this will reduce the accident occurring at nighttime.

4.5.3. TOTAL (KALITI SHOA BAKERY)

Site description: Total is located near to the kaliti shoa bakery. It is surrounded by many residential, commercials, administrative settlements, fuel stations, shops, schools, market areas, Nazareth bus station, and high number of heavy vehicles using the road (especially during early in the morning and late in the evening). Hence, the area practiced the high fatal, serious, slight and property damage accidents, which exacerbate the frequency of causalities and accidents of RTAs in the area. As far as the time is concerned, the highest accident crash occurs at 6 am-8 pm, that is 268 accidents from the total 299 crash numbers. Moreover, 90% of the accident has occurred from Monday to Saturday of the week. The collision types facing on the area are rear end collisions, sideswipe collision and collisions with pedestrians. Photographs of some field observations on the area, which shows deficiencies of the rout contribution exposures for those types of collisions especially for pedestrian and vehicle conflicts, are presented below.

Site inspection:-

- The road marking condition was very poor at almost all sections route, particularly at the travelled way where there was no road marking completely (see Figure **39, 40**).
- The route has faded markings, especially at the pedestrian crossing location, but the overall condition of road marking along the route was terrible (see Figure **40**).
- There was a complete absence of lane marking. The absence of lane marking caused vehicle drivers to leave a particular travelled lane that creates confusion among motorists, and causes a serious accident. There were complete absences of route edge line markings throughout the observed route section, so drivers who use inner lane might mistakenly hit the median edge due to the edge line missing and create accidents (see Figure **40**).
- There was complete absence of transverse markings of the route, and this could lead to serious intersection accidents (see Figure **40**).
- Absence of proper routine maintenance, which caused vehicles to have sudden break or parked on the outer travelled lane that could lead to serious accidents has been observed (see Figure **40**).
- Poor drainage systems and open channels have been observed and these conditions create high potential safety problems to vehicle drivers and vulnerable road users (see Figure **40**).

Figure 39.Photo. Pond of water at the Shoulder and pedestrian walkway, complete absence of lane marking (edge line, median, transverse markings); there were completely absence of pedestrian crossing warning a head sign, and lack of maintenance.

Figure 40.Photo.Ethio. National School students trying to cross the road

Improvement needs:

- In the overall section of the route being inspected, there were completely absence of lane marking, edge lane marking and transverse marking that help in directing and notifying the vehicle drivers and vulnerable road users. The road marking principles should be followed and implemented; proper lane demarcation and transverse markings have to be provided
- Raised Zebra crossing should be providing specially in front of schools (Ethio National School)
- Drainage channels should be covered completely.

- Good routine maintenance should be practiced to reduce sudden break on a travel lane due to rutting, potholes and depression and outer travelled lane parking due to lane edge deteriorations which might contribute massively to accident reduction
- Walkway facilities should be provided on the overall route section in order to protect and separate pedestrian from moving vehicles.

4.5.4. KALITI ROUNDABOUT-TOTAL

Site description: It is 6.1 km long section of road between Kality Roundabout on the Ring Road and Akaki -Total (kaliti Meneharya). It is at urban section of the Addis Ababa- Debrizeit National Trunk Road, which includes high intensity of intercity freight and passenger vehicular traffic passes through the entire road. The road also hosts large tracks movements, which transport export and import commodities, goods, machineries and other services to the county as whole at significant rate. Thus, the area practiced the highest rate of causalities and accidents of RTAs when compared with other road segments. The rear end collisions, sideswipe collision and collisions with pedestrian are the highest.

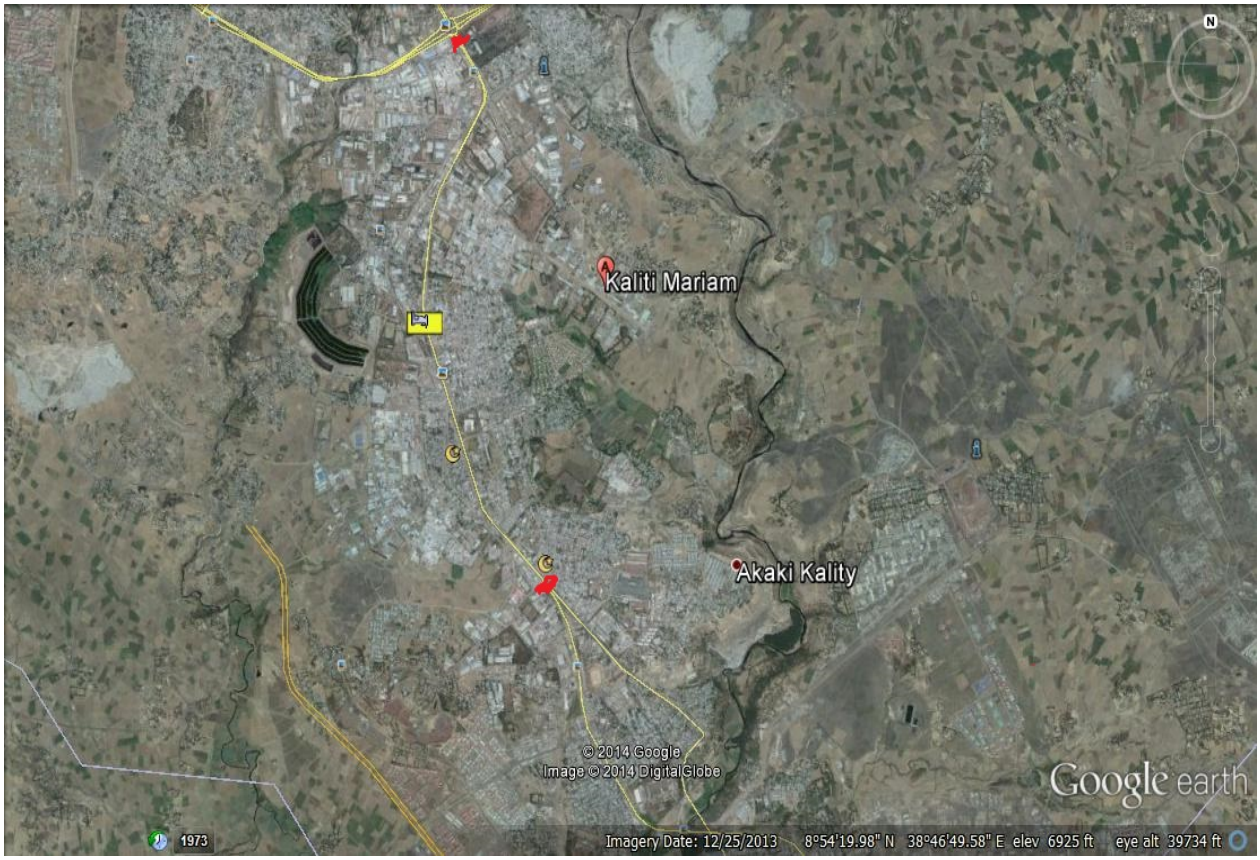


Figure 41: Site of kaliti RA-Total

Field investigations;-

The travel speed is this section in not more than 30 km/h; especially from Akaki round about to Crown hotel is not more than 15 km/h there is high rate of accidents. It is not adequate for the traffic following at these sections exposed specially to high collusion of rear end collusion

Improvement measures needs

In addition to existing roadway (the rout kaliti RA-Crown hotel), it is recommended to have used the unpaved Kadisco paint factory-Crown hotel for one-way movement by providing an new at-grade intersection on the entre of kadisco to dive the flow from roundabout to decrease the congestion and accident rate, and at the same time from kaliti roundabout to Crown hotel. The reverse flow from Addis Ababa Prison to Kality RA could then use the entire existing roadway to ease the congestion and to reduce high rate of accidents on this section.

Figure 42: Kadisco paint factory-Crown hotel

4.5.5. Kaliti Driving Testing Center

Site description: Kaliti driving Testing Center is located near to the Kaliti Roundabout and infront of the country's big NGO office called "CRDA." The frequency of communities to the testing center and to the office are very high and hence, the area practiced the high fatal, serious, slight and property damage accidents, which exacerbates the rate of causalities and accidents of RTAs in the area. As to the time, the highest accident crash occurs at 9 AM-6 PM that is 122 accidents from the 155 crashes. In addition, 99.5% of the accident has occurred from Monday to Saturday day of the week. The collision types facing on the area are rear end collisions, sideswipe collision and collisions with pedestrians.

Figure 43.Photo. Kaliti Driving Testing Center. Overtaking

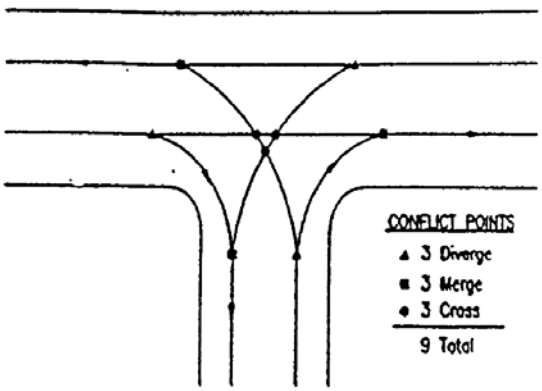
Site inspection:-

- There was no properly constructed side walkway
- The marked ware faded with no sign to road user
- There is no pedestrian crossing marked
- Parking of freight vehicles on road side shoulders
- High intensity of intercity freight and passenger vehicular traffic passes through the entire.

Improvement needs:

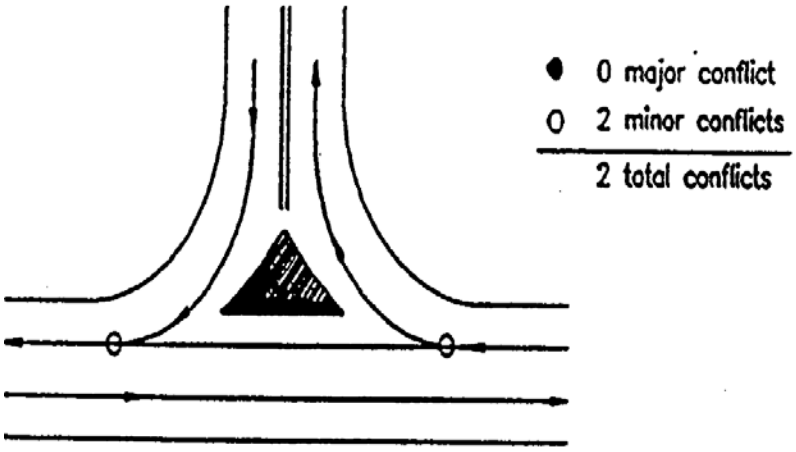
- Widening of the pavement, bus bay, passenger shed, installation of marking, signs, and improvement of intersection should be done.
- Zebra crossing should be marked with vertical signs and horizontal marking
- Warning sign of pedestrian crossing should be placed at zebra crossing on both sides in order to minimizing the accident collision with pedestrians.
- On the time of high crash hour (9 AM-6 PM), traffic police should be available.
- Prohibit overtaking to minimize the rear end collisions and sideswipe collisions.
- The median should be identified by road marking.

Figure 44. Photo. Dust vehicles made it difficult to see.



Conflict points before channelization

Improvement needs: Permitting all movements at this location, which are unsuitable, can sometimes cause congestion and safety problems. To minimize the number of conflict points and hence the opportunities for crashes, channelization is best because collision types facing on the area are rear end collisions and sideswipe collision.



Conflict points after channelization

4.5.6. Cheralia Biscuit Factory

Site description: *Cheralia Biscuit Factory* area, which is also known "cheralia "to the local people, out of 270 accidents recorded, 208 accidents occurred on the week days from Monday to Friday because this is located on the dense traffic areas in which majority of big tracks, commuting workers, and large industries are found. Hence, the movements of the pedestrians are more frequent to come and work in these industries, besides the local communities' massive movement on the road. Thus, the area practiced the highest rate of causalities and accidents of RTAs .The highest crush hours occurred during (8:00 am-6:00 pm) time of the day, and 73% of the total and 87,83,59 no of accidents are due to the collusion type of rear end collisions, sideswipe collision and collision with pedestrians respectively.

Figure 45. Photo. Improper drainages, Lack of pedestrian walkway and truck blocking sidewalk

Site inspection:-

- There was no properly constructed side walkway
- The marked ware faded with no sign to road user
- Parking of freight vehicles on road side shoulders
- High intensity of intercity freight and passenger vehicular traffic passes through the entire

Improvement needs:

- Zebra crossing should be marked with vertical signs and horizontal marking
- Warning sign of pedestrian crossing should be placed at zebra crossing on both sides in order to minimize the accident collusion with pedestrians.
- Prohibit overtaking to minimize the rear end collisions and sideswipe collisions.

4.5.7. Korki (Medroc) Entrance

Site description: *Korki(Medroc) Entrance* is located very near to *Cheralia Biscuit Factory* area which practiced similar crowded traffic movements which dominated by big tracks, commuting factory workers, small, medium and large industries sectors. Besides, there are also high and frequent pedestrians, taxis, and buses movements. Hence, the area practiced the highest fatal, serious and property damage accidents which inflate the frequency of causalities and accidents of RTAs in the area. The highest crush hours occurred during (8:00 AM-7:00 PM) time of the day, and 88% of the total and 91% of accidents are due to the collusion types of rear end collisions, broadside collision, sideswipe collision and collision with pedestrians.

Figure 46. Photo. Complete absence of pedestrian crossing markings, lane marking (edge line, median markings, and transverse), and no pedestrian walkway

Site inspection:-

- There was no properly constructed side walkway
- There is no pedestrian crossing marked
- High intensity of intercity freight and passenger vehicular traffic passes through the entire

Improvement needs:

- Zebra crossing should be marked with vertical signs and horizontal marking
- Warning sign of pedestrian crossing should be placed at zebra crossing on both sides in order to minimize the accident collision with pedestrians.
- Prohibit overtaking to minimize the rear end collisions and sideswipe collisions.
- The median should be identified by road marking.

4.5.8. KALITI St.GEBREAIL CHURCH

Site description: *Kaliti St.Gebreail Church* is located very near to the newly constructed eastern countries/regions bus station which include small, medium, and large buses. In addition, there are to recurrent large tracks movements, which transport export and import commodities, goods, machineries and other services to the county as whole at significant rate. The area also includes T-type unsignalized intersection. Moreover, due to the presence of St. Gebreail church in the area, many Christian followers visit the area frequently on foot, by taking taxis, and by their own vehicles. Therefore, these factors exacerbate the causality and the accident rates of RTAs in the area.

Site inspection

- Absence of controlled pedestrian crossing facilities
- There was no properly constructed side walkway.
- The marked ware faded with no sign to road user.
- Parking of freight vehicles on roadside shoulders
- The route has faded markings, especially at the pedestrian crossing location.
- There was complete absence of transverse markings of the route, which could lead to serious intersection accidents.

- Absence of proper routine maintenance, which caused vehicles to have sudden break or parked on the outer travelled lane, which could lead to serious accidents has been observed.
- There was completely absence of pedestrian crossing warning a head sign on the overall route section.

Figure 47. Photo. Pond of water at the Carriageway, Shoulder and pedestrian walkway missing, complete absence of lane marking (edge line, median, transverse markings), there were completely absence of pedestrian crossing warning a head sign, and lack of maintenance.

Improvement measures

- Zebra crossing should be marked with vertical signs and horizontal marking and should be provided for pedestrians for safe road crossings at appropriate places.
- Warning sign of pedestrian crossing should be placed at zebra crossing on both sides in order to minimize the accident collusion with pedestrians.
- Prohibit overtaking to minimize the rear end collisions and sideswipe collisions.
- Preparation and construction of separate parking areas for the church followers either by church or by any concerned government bodies should be made.

4.5.9. Prison Office Entrance(Crown Hotel)

Site description: Prison Office Entrance (Crown Hotel) is located where two single ways merged to undivided two ways. The frequency of communities to the prison office is very high as it is one of the biggest prison office at federal level in Ethiopia, and the number of automobiles moves and visits the Crown Hotel also has very significant number.

Site inspection

- Inadequate road width with non-uniform road cross-section and this affects traffic flows.
- Absence of controlled pedestrian crossing facilities
- There was no properly constructed side walkway.
- The marked ware faded with no sign to road user.
- Parking of freight vehicles on roadside shoulders
- The road marking condition was very poor at almost all sections route, particularly at the travelled way where there was no road marking completely.
- The route has faded markings, especially at the pedestrian crossing location.
- There was complete absence of transverse markings of the route which could lead to serious intersection accidents)
- Absence of proper routine maintenance, which caused vehicles to have sudden break or parked on the outer travelled lane, which could lead to serious accidents has been observed.

Figure 48. Photo. Faded and invisible pedestrian crossing markings, complete absence of lane marking (edge line, median markings, transverse), and no pedestrian walkway

Improvement measures needs includes;

- Widening of the pavement, bus bay, passenger shed, and installation of marking, signs, and improvement of intersection should be done.
- Zebra crossing should be marked with vertical signs and horizontal marking.
- Warning sign of pedestrian crossing should be placed at zebra crossing on both sides in order to minimize the accident collision with pedestrians.
- Provide and properly constructed side walkway
- Prohibit overtaking to minimize the rear end collisions and sideswipe collisions.
- The median should be identified by road marking.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1. Conclusions

According to findings revealed about Road Traffic accidents in Addis Ababa in general and Akaki-Kaliti Sub-city in particular, the following conclusions are drawn.

- The study implied the existence of large difference in road traffic victims among drivers, passengers, and pedestrians in respect of sexes and ages. That is, male drivers, passengers, and pedestrians were the most affected compared to their female counterparts.
- Moreover, the result confirmed that road traffic accident with regard to death, serious injuries and light injuries in the city mostly affected age categories of between 18-50 regardless of their sex, and started declining after age 50. In this regard, the statistical test result endorses the presence of significant difference on the level of the accidents occurrence basing age factors at *p (0.021)* and chi-square value of *16.42*. This magnifies that the effect of age on the type and level of occurrences of the road traffic accidents in the City is tremendous and changes with the age of the drivers.
- Generally, most of the road traffic accidents were highly affecting the economically active citizens i.e., youths and young adult groups, which, in turn, negatively affects the economy of the country and social structure of the population.

- The road traffic accident trends in the Akaki-Kaliti Sub-City in terms of days of a week revealed significant growth of the severity of the accidents from 2003 to 2005 in all days of the week except on Sunday though there are slight differences.

- Road traffic accidents vary in hours of a day in the Sub-City from 2010/11 -2012/13(2003-2005 E.C), and hence /the crash has reached maximum points when pedestrians, passengers, and drivers frequency of movement increased. Accordingly, accident reports in the Sub City based on crash hour have three basic scenarios, and the researcher named as plateau stage, maximum stage, and decreasing stages. In the first categories, (1:00-5:00) accident

frequencies, more or less, have similar features from 2010/11 to 2012/13 After the plateau stage, especially after 6:00, RTAs started tremendously increasing and reached the maximum accidents at 10:00 in both 2004 and 2005 and at 11:00 in 2003. However, slight decrease occurred from 12:00 to 17:00 in the same way in the three consecutive years, and acutely decreased after 18: 00 and reaches plateau levels in 24:00.

- Moreover, the study confirmed the presence of accident differences in different land uses. For instances, the CBD and Market Areas have very frequent accidents though the remaining land uses like Rural Village Area and Agriculture Area have no accident reports in all the three selected years.

- The study also identifies collision types mostly occurred in the Sub-City, and hence collisions like rear end, sideswipes, broadside, collision with pedestrian, and head on, collisions were the most frequently occurring collisions in the sub city in the 2010/11-2012/13.

- Road junction like midblock junction had the highest and most frequent accident rates as compared to the other junctions with radical increment from 2010/11-2012/13. The Y–junction and T – junctions had also exhibited adequate accidents in the Sub-City.

- Road lane type and quality have crucial important in reducing road traffic accidents. In this regard, the investigation of the data had shown the presence of significant difference in exhibiting road traffic accidents i.e., the highest accident frequency was associated with double carriageway (with median) which was followed by undivided two ways.

- Besides, highest accidents were recorded in straight and level road character in the sub city but road characters like straight and grade, straight with up and down, curve and level, curve and grade, uphill, and downhill did not practice significant accident frequency in the Sub-City.

- The analysis of accident by vehicle type indicates that most of the accidents were caused by Automobile, truck 11-40 quintal, truck 41-100 quintal, truck with trailer, pick up <=10 quintal, minibus up to 12 seats, and bus 13-45 seats.

- Moreover, most of the RTAs occurred in dry road surface conditions rather than in wet road surface conditions.

- Areas like Saris Abo roundabout, Tirunesh Beijing Hospital (Near to Bridge), Customs Office Entrance, Total (Kaliti Shoa Bakery), Korki (Medroc) Entrance, Cheralia Biscuit Factory, and Akaki Kela (Near To UNISA) experienced the highest accident rates (i.e., which were ranked from 1-7 respectively).

- Finally, the study identifies the collisions types in the Selected Black Spot Areas. The types which include rear-end collisions, sideswipe collision, broadside collision, collision with pedestrians, head-on collision , rollover, collision with animals, fall from vehicles, collision with roadside parked vehicles, collision with road side objects, and collision with train though their degree of occurrences varies.

- As a result, the trends in serious accidents, slight accident, and property damage dramatically increased in all the collision types except collision with animals, fall from vehicles, collision with roadside-parked vehicles, and collision with roadside objects.

5.2. Recommendations

On the basis of the findings of the study and conclusions, the following recommendations were drawn.

- As the study findings confirm, majority of the RTAs in the city and Sub-City affect all communities, but the extent to which they affect children, youths, and young adults is overwhelming. Thus, road safety education should be provided in the schools, work areas, and even using mass medias in the city as a short-term solution. But, in the long run, this should be included in the school curricula, and widely addressed at national mass medias, a including the private medias.

- Due to the lack of a definite land use policy in the City in general and sub city in particular, the concentration of industrial areas, commercial activities, government offices and other big services such as hotels, hospitals and schools has exacerbated the occurrences of road traffic accidents. Thus, the city administration is expected to decentralize function by giving special consideration of land use ways to the sub city level so that the Sub-City allocates different land uses to appropriately mange and reduce RTAs.

- The analysis of the study verifies that driver casualties are among the dominant causes of RTAs. The young, and less experienced drivers are responsible for most of the accidents happened. Therefore, drivers' training and testing should be standardized; a longer minimum time of driving experience should be imposed before a license is issued to a driver. In addition, there should be additional prerequisite criteria for drivers with regard to their educational background and good behavior, maturity of their age, ample driving experience, free from any addiction like chewing chat, alcoholic drinks, free from criminal acts as well as offending and frequent violation of traffic regulations.

- Besides, most of the highest accidents in the Sub-City and selected Black spot areas happened in day light within 7:00-17:00 (7 am-5 pm), Therefore, there should be a restriction for long vehicles' movements, especially that come from Djibouti to Addis and

vice versa. They may be subjected to move when the RTAs identified as very low between 18:00-1:00. Otherwise, some penalties should be put in place.

- As the job done on pedestrian in some parts of our country shows significant awareness improvements about RTAs and pedestrians started using their right or left side properly when vehicles come. The same Public Road user education and awareness raising should be given with the necessary attention. Pedestrian traffic education should be offered and encouraged through the radio, television, newspapers, magazines, books, films, leaflets and posters as well as giving traffic education around schools, work areas, worship places and public gatherings, and the like.

- The scarcity of traffic signals such as traffic lights and their frequent technical failure creates chaos at squares and junctions leading to the incidence of traffic accidents. Therefore, in addition to the maintenance of the existing ones, the expansion of traffic lights to other accident-prone squares and junctions should receive immediate response.

- Based on deep understanding of the main causes of accidents, the engineering solutions should be considered to minimize the current high frequency of accidents at the Black spots for the most ranked areas particularly for black spots, proposed details in the analysis and discussion parts were given. To summarize, the following recommendations should be implemented.
    - Raised Zebra crossing should be provided specially in front of schools
    - Zebra crossing should be marked with vertical signs and horizontal marking.
    - Warning sign of pedestrian crossing should be placed at zebra crossing on both sides.
    - Preparation and construction of separate parking areas for the church followers either by church or by any concerned government bodies should be made.
    - Provide and properly constructed side walkway.
    - Provide fence to lead the pedestrian

- Widening of the pavement, bus bay, passenger shed, installation of marking, signs, and improvement of intersection should be done
- Promote to use bright color for school uniforms.
- Prohibition of on road side parking
- Traffic channelization.
- On the time of high crash hour, (9 AM-6 PM), strict traffic police enforcement.
- The median should be identified by road marking.
- Enforce street shopping and neighbor stores not to sell or Place some goods on the sidewalks.
- Trimming trees from inner side of road.
- Provide new guard fencing at the approach of the bridge.
- Provide street lighting, and pedestrian crossing lighting.

CHAPTER SIX

PROPOSED FUTURE RESEARCH AREAS

This section provides a set of recommendations on the possible extensions to this research as follows:

- Road traffic accidents cost the country a lot of resources in terms of deaths, injuries and destruction of property. I recommend further research on the detailed information about total costs of accidents in Addis Ababa.

- This analysis was conducted using one from the two key approaches traffic engineering road safety that is namely the hazardous road location approach achieve crash reduction through the development of remedial measures. I recommend further research using a second approach that based upon the concept of road safety audit aimed at crash prevention in order to evaluate the overall safety condition of the road network in Akaki-Kaliti Sub-City.

- Human error is a contributing factor in over 96% of road traffic accidents. Human error is because of human behavior and attitudes towards driving. I would recommend further research in the relevant incentive scheme that would influence Ethiopian's professional drivers' attitudes and behaviors on the road.

- The road transport regulation in Ethiopia was absence of activities to regularly update. I recommend further research on the effects of transport regulation and policy on the safety performance of the road transport industry in Ethiopia.

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APPENDICES

Appendix 1: Actual and compiled data of Addis Ababa

Table A-30 Projected total, Addis Ababa population size (in thousands) by sex, year, and medium variant: 2008-2037

YEAR	Urban + Rural			Urba			Rural		
	Total	Male	Female	Total	Male	Female	Male	Female	
2008	2,792	1,333	1,459	2,792	1,333	1,459	-	-	-
2009	2,851	1,359	1,492	2,851	1,359	1,492	-	-	-
2010	2,912	1,386	1,526	2,912	1,386	1,526	-	-	-
2011	2,977	1,415	1,562	2,977	1,415	1,562	-	-	-
2012	3,046	1,447	1,599	3,046	1,447	1,599	-	-	-
2013	3,119	1,480	1,639	3,119	1,480	1,639	-	-	-
2014	3,194	1,515	1,679	3,194	1,515	1,679	-	-	-
2015	3,272	1,551	1,722	3,272	1,551	1,722	-	-	-
2016	3,353	1,588	1,765	3,353	1,588	1,765	-	-	-
2017	3,435	1,625	1,810	3,435	1,625	1,810	-	-	-
2018	3,519	1,664	1,855	3,519	1,664	1,855	-	-	-
2019	3,604	1,703	1,900	3,604	1,703	1,900	-	-	-
2020	3,689	1,743	1,946	3,689	1,743	1,946	-	-	-
2021	3,774	1,782	1,992	3,774	1,782	1,992	-	-	-
2022	3,860	1,822	2,038	3,860	1,822	2,038	-	-	-
2023	3,945	1,861	2,084	3,945	1,861	2,084	-	-	-
2024	4,030	1,900	2,130	4,030	1,900	2,130	-	-	-
2025	4,114	1,939	2,175	4,114	1,939	2,175	-	-	-
2026	4,198	1,977	2,221	4,198	1,977	2,221	-	-	-
2027	4,281	2,015	2,266	4,281	2,015	2,266	-	-	-
2028	4,364	2,053	2,311	4,364	2,053	2,311	-	-	-
2029	4,447	2,091	2,356	4,447	2,091	2,356	-	-	-
2030	4,530	2,128	2,402	4,530	2,128	2,402	-	-	-
2031	4,613	2,166	2,447	4,613	2,166	2,447	-	-	-
2032	4,697	2,204	2,492	4,697	2,204	2,492	-	-	-
2033	4,781	2,242	2,539	4,781	2,242	2,539	-	-	-
2034	4,866	2,281	2,585	4,866	2,281	2,585	-	-	-
2035	4,953	2,320	2,633	4,953	2,320	2,633	-	-	-
2036	5,041	2,359	2,682	5,041	2,359	2,682	-	-	-
2037	5,132	2,400	2,732	5,132	2,400	2,732	-	-	-

Data Source: Central Statistical Agency Population Projections for Ethiopia 2007-2037

N. B: The year in Table A-30 and Table A-34 is presented in European calendar and the remaining tables includes year in Ethiopia calendar.

Table A-31: Addis Ababa accident fatalities

YEAR	KILLED	VEHICLES REGISTER	LICENSE HOLDERS	POPULATION (000)	FATALITIES PER		
					10,000 VEHICLES	10,000 LICENSES	100,000 POPULATION
2001	371	223161	403890	2792	16.6	9.2	13.3
2002	318	245357	418798	2851	13	7.6	11.2
2003	332	266603	441968	2912	12.5	7.5	11.4
2004	369	291096	466722	2977	12.7	7.9	12.4
2005	367	319979	493367	3046	11.5	7.4	12.0

Data Source: Addis Ababa road and transport offices and Central Statistical Agency; compiled by author

Table A-32: License holders in Addis Ababa up to 2005

YEAR	BEFORE 2001	2001	2002	2003	2004	2005	TOTAL
MALE	287314	291335	303317	322009	342715	365335	287314
FEMALE	111943	112555	115481	119959	124007	128032	111943
TOTAL	399257	403890	418798	441968	466722	493367	399257

Data Source: Addis Ababa road and transport offices; compiled by author

Table A-33: Vehicles register in Addis Ababa up to 2005

YEAR	BEFORE 2001	2001	2002	2003	2004	2005
VEHICLES ON REGISTER	202151	223161	245357	266603	291096	319979

Data Source: city government of Addis Ababa road and transport; compiled by author

Table A-34: Base year population (in thousands) by sex and age group, Addis Ababa region: july 1, 2007

Age Group	Urban+Rural			Urban			Rural		
	Total	Male	Female	Total	Male	Female	Total	Male	Female
All Ages	2735.5	1307.8	1427.7	2735.5	1307.8	1427.7	-	-	-
0-4	198.3	100.8	97.5	198.3	100.8	97.5	-	-	-
5-9	210.3	102.0	108.3	210.3	102.0	108.3	-	-	-
10-14	250.7	109.2	141.5	250.7	109.2	141.5	-	-	-
15-19	386.5	153.5	233.0	386.5	153.5	233.0	-	-	-
20-24	405.9	184.8	221.1	405.9	184.8	221.1	-	-	-
25-29	371.9	180.0	191.9	371.9	180.0	191.9	-	-	-
30-34	233.3	126.3	107.0	233.3	126.3	107.0	-	-	-
35-39	189.4	98.3	91.1	189.4	98.3	91.1	-	-	-
40-44	120.3	65.9	54.4	120.3	65.9	54.4	-	-	-
45-49	102.4	51.1	51.3	102.4	51.1	51.3	-	-	-
50-54	80.8	39.0	41.8	80.8	39.0	41.8	-	-	-
55-59	55.3	28.3	27.0	55.3	28.3	27.0	-	-	-
60-64	47.5	23.9	23.6	47.5	23.9	23.6	-	-	-
65-69	34.8	17.9	16.9	34.8	17.9	16.9	-	-	-
70-74	26.5	12.7	13.8	26.5	12.7	13.8	-	-	-
75-79	13.6	6.8	6.8	13.6	6.8	6.8	-	-	-
_80+	8.0	7.3	0.7	8.0	7.3	0.7	-	-	-

Data source: central statistical agency population Addis Ababa region

Table A-35: Population (in thousands) by age group, Addis Ababa region

age group	population	total	percentage
<7	198.3+84.12	282.42	10.3%
7-13	126.18+200.56	326.74	11.9%
14-17	50.14+231.9	282.04	10.3%
18-30	154.6+405.9+371.9+46.66	979.06	35.8%
31-50	186.64+189.4+120.3+102.4+16.16	614.9	22.5%
>50	64.64+55.3+47.5+34.8+26.5+13.6+8	250.34	9.2%
total	2735.5		100%

Data Source: Central Statistical Agency; compiled by author

Table A-36: Traffic accident by road user type 2001-2002

			2001						2002					
			deaths		Serious injury		light injury		deaths		Serious injury		light injury	
no	accident	age	male	female	male	female	male	female	male	female	male	female	male	female
	Derivers	<18	2		1				1		1			
		18-30	7		23	1	21		5		11		19	1
		31-50	5		20	1	31		5		13	3	19	
1		>50	1		4		9		2		4		1	
		sub-Total	15		48	2	61		13		29	3	39	1
	Pedestrians	<7	12	5	24	6	6	2	3	4	16	3	1	2
		7-13	9	8	48	22	19	10	15	5	30	8	24	14
		14-17	9	2	22	13	20	10	3		31	11	55	12
		18-30	94	19	176	76	153	73	68	24	181	70	214	78
		31-50	86	16	118	39	86	30	78	16	119	24	101	41
2		>50	54	23	76	41	46	16	53	17	68	28	46	14
		sub-Total	264	73	464	197	330	141	220	66	445	144	441	161
	Passengers	<7		1			1	1						
		7-13			2		3		2		7	1	3	4
		14-17			5	1	3	1	1	1	2		1	2
		18-30	15	4	43	23	74	34	16	2	40	11	51	23
		31-50	3	2	31	13	47	18	15	3	12	9	26	13
3		>50	2		4	2	13	2	1		3	1	11	2
		sub-Total	20	7	85	39	141	56	35	6	64	22	92	44
Total			299	80	597	238	532	197	268	72	538	169	572	206

Data Source: -Addis Ababa Police Commission; compiled by author

Table A-37: Traffic accident by road user type 2003-2004

no	accident	age	2003						2004					
			deaths		Serious injury		light injury		deaths		Serious injury		light injury	
			male	female	male	female	male	female	male	female	male	female	male	female
	Derivers	<18			1									
		18-30	4		6		6		1		21	5	26	3
		31-50	4		7		5		2		18	2	13	1
1		>50	1		4		3		1		6	2	6	3
sub-Total			9		18		14		4		45	9	45	7
	Pedestrians	<7	9	5	3	2	2	1	4	5	13	15	3	3
		7-13	8	5	42	33	25	9	11	9	56	30	17	22
		14-17	13	10	65	17	47	25	9	4	85	48	45	24
		18-30	75	28	270	62	271	80	118	14	362	168	322	71
		31-50	84	19	212	46	139	30	107	10	222	51	136	66
2		>50	56	25	163	31	76	23	55	30	120	36	84	39
sub-Total			245	92	755	191	560	168	304	72	858	348	607	225
	Passengers	<7		1	6	3	3			1				
		7-13					2				4	3		
		14-17			9	2	13	3			8	1	7	2
		18-30	8	8	36	11	39	7	9	2	53	22	68	27
		31-50	2	3	30	4	18	5	14	1	47	17	28	11
3		>50			6	4	10	4	2	2	15	6	18	3
sub-Total			10	12	87	24	85	19	25	6	127	49	121	43
Total			264	104	860	215	659	187	333	78	1030	406	773	275

Data Source: -Addis Ababa Police Commission; compiled by author

Table A-38: Traffic accident by road user type 2005

No	Accident	Age	2005					
			deaths		Serious injury		light injury	
			male	female	male	female	male	female
	Derivers	<18						
		18-30	14		19		23	1
		31-50	7		19		13	1
1		>50	1		2		3	
		sub-Total	22		40		39	2
	Pedestrians	<7	6	3	9	4	3	1
		7-13	11	5	63	18	55	27
		14-17	7	6	107	46	95	28
		18-30	78	25	482	110	446	149
		31-50	73	16	199	59	177	64
2		>50	73	26	103	47	69	41
		sub-Total	248	81	963	284	845	310
	Passengers	<7					1	
		7-13			1	1	3	
		14-17	1		17	8	14	5
		18-30	11	4	78	33	79	16
		31-50	6		42	14	46	11
3		>50	1		9	2	7	3
		sub-Total	19	4	147	58	150	35
Total			289	85	1150	342	1034	347

Data Source: -Addis Ababa Police Commission; compiled by author

Table A-39: Chi-square test result of sex of the drivers and frequency of accident

sex of the drivers

sex of the drivers	Observed N	Expected N	Residual
male	392	308.6	83.4
female	25	108.4	-83.4
Total	417		

Test Statistics

	sex of the drivers
Chi-Square	86.736
df	1
Asymp. Sig.	.000

Decision The above Table shows a calculated χ 2 - value of 86.736 for 1 df. In addition, a critical χ 2 - value of 3.841 at 0.05 alpha level. Since the calculated χ 2 - value is greater than the critical .The null hypothesis independency between the accident and sex of the drivers is rejected at p value<0.05. It is evident that the accident is highly related with driver's sex

Table A-40: Chi-square test result of age group of the drivers and frequency of accident

Age Categorized

Age-group	Observed N	Expected N	Residual
<18	6	104.3	-98.3
18-30	175	104.3	70.8
31-50	183	104.3	78.8
>50	53	104.3	-51.3
Total	417		

Test Statistics	age categorized
Chi-Square	225.293
df	3
Asymp. Sig.	.000

Decision The above table **Table A-40** shows a calculated χ 2 - value of 225.293 for 3 df. In addition, a critical χ 2 - value of 7.815 at 0.05 alpha levels. Since the calculated χ 2 - value is greater than the critical .The null hypothesis independency between the accident and Age group of the drivers is rejected at p value=.000<0.05. It is evident that the accident is highly related with Age group of the drivers.

Table A-41: Chi-square test result of Age of passenger sufferers and frequency of accident

Age of passenger sufferers

Age-group	Observed N	Expected N	Residual
<7	18	168.1	-150.1
7-13	36	194.2	-158.2
14-17	107	168.1	-61.1
18-30	847	584.3	262.7
31-50	491	367.2	123.8
>50	133	150.1	-17.1
Total	1632		

Test Statistics

	Age of passenger sufferers
Chi-Square	446.965
df	5
Asymp. Sig.	.000

Decision The above table**Table A-41** shows a calculated χ 2 - value of 446.965 for 5 df. Moreover, a critical χ 2 - value of 11.070 at 0.05 alpha levels. Since the calculated χ 2 - value is greater than the critical χ 2 - value .The null hypothesis independency between the accident and Age of passenger is rejected at p value<0.05. It is evident that the accident is highly related with Age of passenger.

Table A-42: Chi-square test result of Age of Pedestrians sufferers and frequency of accident

Age of Pedestrians sufferers

Age-group	Observed N	Expected N	Residual
<7	175	1040.5	-865.5
7-13	658	1202.1	-544.1
14-17	869	1040.5	-171.5
18-30	4357	3616.5	740.5
31-50	2464	2273.0	191.0
>50	1579	929.4	649.6
Total	10102		

Test Statistics

	Age of Pedestrians sufferers
Chi-Square	1616.246
df	5
Asymp. Sig.	.000

Decision The above table **Table A-42** shows a calculated χ 2 - value of 1616.246 for 5 df. In addition, a critical χ 2 - value of 11.070 at 0.05 alpha levels. Since the calculated χ 2 - value is greater than the critical .The null hypothesis independency between the accident and Age of Pedestrians is rejected at p-value = 0.000 ≤ 0.05. It is evident that the accident is highly related with Age of Pedestrians.

Table A-43: Causes of road traffic accidents in Addis Ababa as identified by police

Possible reasons	total 2001-2005				Total	Percent	
	Fatal	Serious	Slight	Property Damage			
drunk driving	0	27	19	830	876	1.77	
drug driving	0	2	3	407	412	0.83	
driving without respecting right hand rule	86	164	179	3760	4189	8.44	
failure to give way for vehicle	31	131	168	10792	11122	22.42	
failure to give way for pedestrian	1295	3530	2968	856	8649	17.43	
followed too closely	42	204	145	9939	10330	20.82	
overtaking on crust vertical curve	0	9	2	473	484	0.98	
overtaking on winding horizontal curve	0	40	25	234	299	0.60	
cut in sharply after overtaking	1	26	16	540	583	1.18	
driving above speed limit	16	54	38	1323	1431	2.88	
improper overtaking	12	51	48	2393	2504	5.05	
improper turning	43	113	130	3443	3729	7.52	
no respect traffic rules	1	0	0	163	164	0.33	96.13
failure to respect light signal	0	5	6	187	198	0.40	
failure to respect stop sign	1	5	9	211	226	0.46	
failure to respect right of way	1	28	35	359	423	0.85	
Improper starting from parked position	44	45	49	1436	1574	3.17	
Wrong/improper parking	5	7	8	137	157	0.32	
Asleep or fatigued or sick	0	2	0	63	65	0.13	
Inattentive or attention diverted the moment	0	4	0	9	13	0.03	
Improper use of head lights-causing glare	0	3	1	18	22	0.04	
Excess loading	17	32	16	177	242	0.49	
Defective brakes	3	7	6	21	37	0.07	
Puncture tyres	0	1	5	16	22	0.04	
burst tiers	0	1	2	3	6	0.01	0.34
Defective steering	14	5	6	77	102	0.21	
Defective road environment	0	0	0	36	36	0.07	0.07
Pedestrian error	1	46	52	0	99	0.20	0.2
other	20	57	46	470	593	1.20	
Unidentified	124	188	160	551	1023	2.06	
total	1757	4787	4142	38924	49610	100	

Source: -Addis Ababa Police Commission, Road Traffic Accident Statistics Office

Table A-44: Total vehicles fleet by vehicle type in Addis Ababa up to 2005

Vehicle type	Total Up to 2005	% of the total
Bicycle	6186	1.9
motor bicycle	5060	1.6
Automobile	106712	33.0
station wagon	49539	15.3
pick up <=10 quintal	40927	12.7
truck 11-40 quintal	37838	11.7
truck 41-100 quintal	14883	4.6
truck with trailer	12619	3.9
Liquid Cargo	6312	2.0
Taxi	10167	3.1
minibus up to 12 seats	11750	3.6
bus 13-45 seats	3168	1.0
bus>46 seats	9112	2.8
Others	9130	2.8
unknown		
Total	323403	

Source: -City Government of Addis Ababa Road and Transport

Appendix 2: Actual and compiled data of Akaki-kalitii Sub -City

Table B-45: Traffic count on motorized vehicle by the Author

Sections	Cars	Land Rover	Small Buses	Large Buses	Small Truck	Medium Truck	Heavy Truck	Truck Trailer	Total
KALITI ROUNDABOUT-TOTAL	5675	6703	6802	5246	6638	7393	7952	6854	53263
KALITI ROUNDABOUT	5961	6896	6987	5379	6988	7683	7976	6995	54865
KALITI DRIVING TESTING CENTER	5675	6703	6802	5246	6638	7393	7952	6854	53263
WATER DEVELOPMENT	5675	6703	6802	5246	6638	7393	7952	6854	53263
KORKI(MEDROC) ENTRANCE	5675	6703	6802	5246	6638	7393	7952	6854	53263
PRISON OFFICE ENTRANCE(CROWN HOTEL)	5675	6703	6802	5246	6638	7393	7952	6854	53263
KALITI St.GEBREAIL CHURCH	5675	6703	6802	5246	6638	7393	7952	6854	53263
CHERALIA BISCUIT FACTORY	5675	6703	6802	5246	6638	7393	7952	6854	53263
TOTAL(KALITI SHOA BAKERY	5675	6703	6802	5246	6638	7393	7952	6854	53263
TOTAL-KIDINAMIHIRET - KELA	2746	3027	4028	2514	4415	3239	3252	6854	30075

KIDINAMIHIRET CHURCH(SELAM Buldg)	2746	3027	4028	2514	4415	3239	3252	6854	30075
TIRUNESH BEIJING HOSPITAL(NEAR THE BRIDGE)	2746	3027	4028	2514	4415	3239	3252	6854	30075
AKAKI KELA(NEAR UNISA)	2746	3027	4028	2514	4415	3239	3252	6854	30075
TOTAL-DERARTU-AKAKI MARKET-KELA-TULU DMTU	2100	2858	2835	2352	2813	2332	2103	7754	25147
DERARTU SCHOOL ENTRANCE	2100	2858	2835	2352	2813	2332	2103	7754	25147
AKAKI MARKET	1401	2397	2243	1629	2246	1650	1456	7125	20147
BELAY AB-KALITI ROUNDABOUT	6324	7620	7250	2304	3501	3230	3752	6854	40835
ADDIS TYRE	6324	7620	7250	2304	3501	3230	3752	6854	40835
AGRICULTURAL MARKETING ENTRANCE	6324	7620	7250	2304	3501	3230	3752	6854	40835
SARIS ABO ROUNDABOUT	7635	8918	8543	3659	4732	4541	4871	7936	50835
CUSTOMS OFFICE ENTRANCE	6324	7620	7250	2304	3501	3230	3752	6854	40835

Table B-46 AADT on Akaki-Kaliti- Road

1. At Kaliti

Year	Cars	Land Rover	Small Buses	Large Bus	Small Truck	Medium Truck	Heavy Truck	Truck Trailer	Total	Growth over previous year (%)
2010	4456	5350	5392	4038	4890	5566	5514	5385	40591	18.1
2009	4447	5221	5511	2853	3691	4443	4043	4164	34373	-1.3
2008	4358	5103	5610	2808	3807	4635	4072	4418	34811	9.6
2007	4029	4844	5300	2440	3445	4020	3699	3998	31775	19.4
2006	3518	3947	4481	2170	2615	3436	3171	3266	26604	22.1
2005	2286	2962	2814	2134	2741	2982	2910	2965	21794	27.2
2004	1944	2719	2832	1686	1673	2132	2255	1894	17135	21.8
2003	1632	2194	2104	1343	1349	1948	1786	1709	14065	9.5
2002	1624	2115	2249	1259	1359	1497	1526	1210	12839	-13.9
2001	1783	2212	2270	1537	1565	1815	1937	1795	14914	
Average Annual Growth Rate										**12.5**

2. At Akaki

Year	Cars	Land Rover	Small Buses	Large Bus	Small Truck	Medium Truck	Heavy Truck	Truck Trailer	Total	Growth over previous year (%)
2010	2279	2601	2687	1834	2591	2524	2339	2603	19458	6.8
2009	2145	2577	2765	1479	2254	2370	2183	2451	18224	15.0
2008	1871	2086	2215	1609	1884	1988	1929	2259	15841	12.7
2007	1841	2123	1870	1343	1030	1957	1526	2361	14051	-5.8
2006	1678	2024	2015	1256	1778	2186	1920	2054	14911	37.6
2005	1248	1551	1238	1141	930	1701	1497	1531	10837	16.0
2004	1398	1750	822	832	466	1485	1424	1162	9339	7.7
2003	1317	1644	748	749	562	1279	1443	928	8670	19.0
2002	1118	1458	584	598	422	967	1283	853	7283	8.7
2001	1035	1397	500	513	459	872	1134	790	6700	
Average Annual Growth Rate										**13.1**

Source: ERA

Table B-47 Accident by roadway surface condition

Roadway surface condition	Akaki -kaliti			
	year			2003-2005
	2003	2004	2005	
dry	874	1217	1548	3639
wet	42	31	11	84
slush	0	0	0	0
unidentified	0	0	0	0
total	916	1248	1559	3723

Table B-48 Accident by type of vehicle defect

Type of vehicle defect	Akaki- Kaliti			
	year			
	2003	2004	2005	2003-2005
defective brakes	3	0	0	3
defective steering	0	0	0	0
punctured or burst tires	0	1	0	1
lighting system	0	0	0	0
other serious mechanical defect	0	0	0	0
without any defected	890	1223	1551	3664
unknown	23	24	8	55
total	916	1248	1559	3723

Table B-49 Accident by light condition

Light condition	Akaki- Kaliti			
	year			
	2003	2004	2005	2003-2005
day light	764	1071	1360	3195
dawn	2	0	0	2
dusk	6	2	2	10
dark-road lighted	47	62	67	176
dark-road weak lighted	34	53	102	189
dark-road unlighted	63	60	28	151
unidentified	0	0	0	0
total	916	1248	1559	3723

Data Source: Akaki-Kaliti Sub-City Police Office; compiled by author

Table B-50 Accident by road character

Road character	Akaki- kaliti			
	Year			
	2003	2004	2005	2003-2005
straight and level	778	1221	1553	3552
straight and grade	69	7	1	77
straight with up and down	16	4	0	20
curve and level	18	5	0	23
curve and grade	0	0	0	0
up hill	6	4	1	11
down hill	27	7	4	38
unidentified	2	0	0	2
total	916	1248	1559	3723

Table B-51 Accident by road junction type

Road junction type	Akaki-kalit			
	Year			
	2003	2004	2005	2003-2005
midblock	462	582	933	1977
y-junction	126	194	171	491
T-junction	150	169	184	503
roundabout	79	165	182	426
four leg junction	59	136	89	284
five leg junction	37	2	0	39
rail crossing	0	0	0	0
unidentified	3	0	0	3
total	916	1248	1559	3723

Table B-52 Accident by road lane type

Road lane type	Akaki-kalit			
	Year			
	2003	2004	2005	2003-2005
one way	86	37	5	128
undivided two-way	162	139	9	310
double carriageway(with median)	519	1063	1542	3124
two-way(divided with solid lines road marking)	110	5	2	117
two-way(divided with broken line road marking)	39	4	1	44
total	916	1248	1559	3723

Data Source: Akaki-Kaliti Sub-City Police Office; compiled by author

Table B-53 Accident by land use

Land use	Akaki-kalit			
	Year			
	2003	2004	2005	2003-2005
rural village area	0	0	0	0
agriculture area	0	0	0	0
school area	12	10	2	24
industrial	9	3	0	12
church areas	39	25	3	67
market areas	119	38	5	162
recreation area	18	11	3	32
hospital area	12	2	0	14
CBD	657	1143	1544	3344
URBAN RESIDENTIAL	46	16	2	64
other	4	0	0	4
total	916	1248	1559	3723

Table B-54 Accident by collisions type

Collision type	At Akaki-kalit			
	Year			
	2003	2004	2005	2003-2005
head on collisions	52	48	21	121
rear end collisions	216	333	466	1015
broadside collision	134	202	245	581
sideswipe collision	196	326	464	986
rollover	22	41	38	101
collision with pedestrians	171	157	187	515
collision with animals	19	0	0	19
fall from vehicles	4	4	0	8
collision with roadside parked vehicles	2	1	5	8
collision with road side objects	81	121	118	320
collision with train	0	0	0	0
others	8	1	1	10
unknown	11	14	14	39
total	916	1248	1559	3723

Data Source: Akaki-Kaliti Sub-City Police Office; compiled by author

Table B-55 Accident by vehicle type (Akaki-Kaliti)

Vehicle Type (by transport mode)	Year			Total
	2003	2004	2005	2003-2005
Bicycle	4	7	1	12
Motor bicycle		10		10
Automobile	178	188	248	614
Station wagon	20	78	65	163
Pick up <=10 quintal	75	101	169	345
Truck 11-40 quintal	174	246	242	662
Truck 41-100 quintal	120	154	201	475
Truck with trailer	98	137	211	446
Liquid Cargo	16	23	35	74
Taxi	27	12	198	237
Minibus up to 12 seats	74	156	12	242
Bus 13-45 seats	70	66	80	216
Bus>46 seats	19	32	52	103
Earth moving	3	6	10	19
Earth moving with trailer				0
Cart	18	11		29
Train			8	8
Others			3	3
Unknown	20	21	24	65
Total	916	1248	1559	3723

Data Source: Akaki-Kaliti Sub-City Police Office; compiled by author

Table B-56: Calculation for Chi-Square

Hours	Observed frequency	Expected frequency	d.f.	Critical χ^2	Calculated χ^2
6.00 AM - 12.00 PM	1404	930.8	3	7.815	1410.882
12.00 PM - 6.00 PM	1563	930.8			
6.00 PM - 12.00 AM	576	930.8			
12.00 AM - 6.00 AM	180	930.8			
Total	3723		Sig.	0.05	0.000

Table B-56 above shows calculated χ 2 - value of 1410.882 for 3 d.f. and a critical χ 2 - value of 7.815 at 0.05 alpha level. Since the calculated χ 2 - value is greater than the critical χ 2 - value, the null hypothesis i.e. accidents are uniformly distributed over the hours of the day is rejected. Thus, it indicates that accidents are not uniformly distributed over the hours of the day.

Crash Hour

	Observed N	Expected N	Residual
6.00 AM - 12.00 PM	1404	930.8	473.3
12.00 PM - 6.00 PM	1563	930.8	632.3
6.00 PM - 12.00 AM	576	930.8	-354.8
12.00 AM - 6.00 AM	180	930.8	-750.8
Total	3723		

Test Statistics

	Crash Hour
Chi-Square	1410.882
df	3
Asymp. Sig.	.000

The present study recorded more than 79.7% of the accidents during daytime (6 AM to 6 PM). These times coincide with the period when people are more active and mobile. The peak time was between 12 PM to 6 PM (41.98%; Table **B-56**). These hours are the busiest as there is heavy rush of commuters from schools, offices, factories, business places, etc. Between 6 AM to 12 PM, also a high number of RTAs were observed that is 37.71%; (Table **B-56**). During this period, the roads are pened for heavy vehicular movements.

Table B-57 number of accident 2003-2005 by day of the week

Day of the week

	Observed N	Expected N	Residual
week day	2878	2658.2	219.8
week end	845	1064.8	-219.8
Total	3723		

Test Statistics

	Day of the week
Chi-Square	63.535
df	1
Asymp. Sig.	.000

Table B-58 Surface Conditions

	Observed N	Expected N	Residual
dry	3639	2784.8	854.3
wet	74	928.3	-854.3
Total	3713		

Test Statistics

	Surface Conditions
Chi-Square	1048.199
df	1
Asymp. Sig.	.000

Table B-59 Calculation of Chi-Square by interval of hours

Hours	Observed frequency	Expected frequency	d.f.	Critical χ^2	Calculated χ^2
6.00 AM - 12.00 PM	15	16.25	3	7.815	15.43
12.00 PM - 6.00 PM	25	16.25			
6.00 PM - 12.00 AM	21	16.25			
12.00 AM - 6.00 AM	4	16.25			
Total	65	Sig.		0.05	0.000

Table B-60 Mode of transport

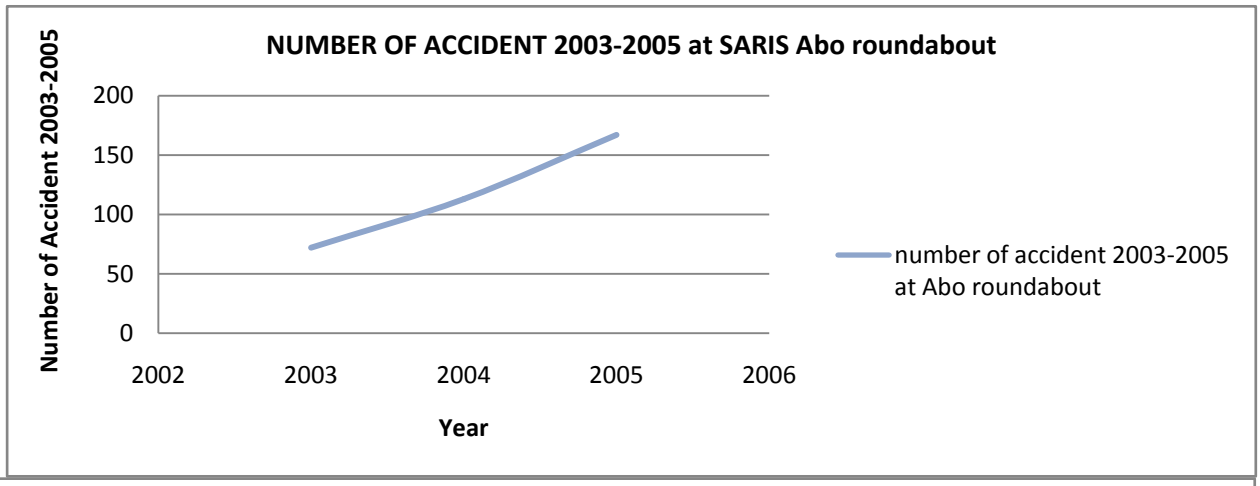
	Observed N	Expected N	Residual
Bicycle	12	71.5	-59.5
Motor bicycle	10	71.5	-61.5
Automobile	614	1179.9	-565.9
Station wagon	163	536.3	-373.3
Pick up <=10 quintal	345	464.8	-119.8
Truck 11-40 quintal	662	429.1	232.9
Truck 41-100 quintal	475	178.8	296.2
Truck with trailer	446	143.0	303.0
Liquid Cargo	74	71.5	2.5
Taxi	237	107.3	129.7
Minibus up to 12 seats	242	143.0	99.0
Bus 13-45 seats	216	35.8	180.2
Bus>46 seats	103	107.3	-4.3
Others	48	107.3	-59.3
Total	3647		

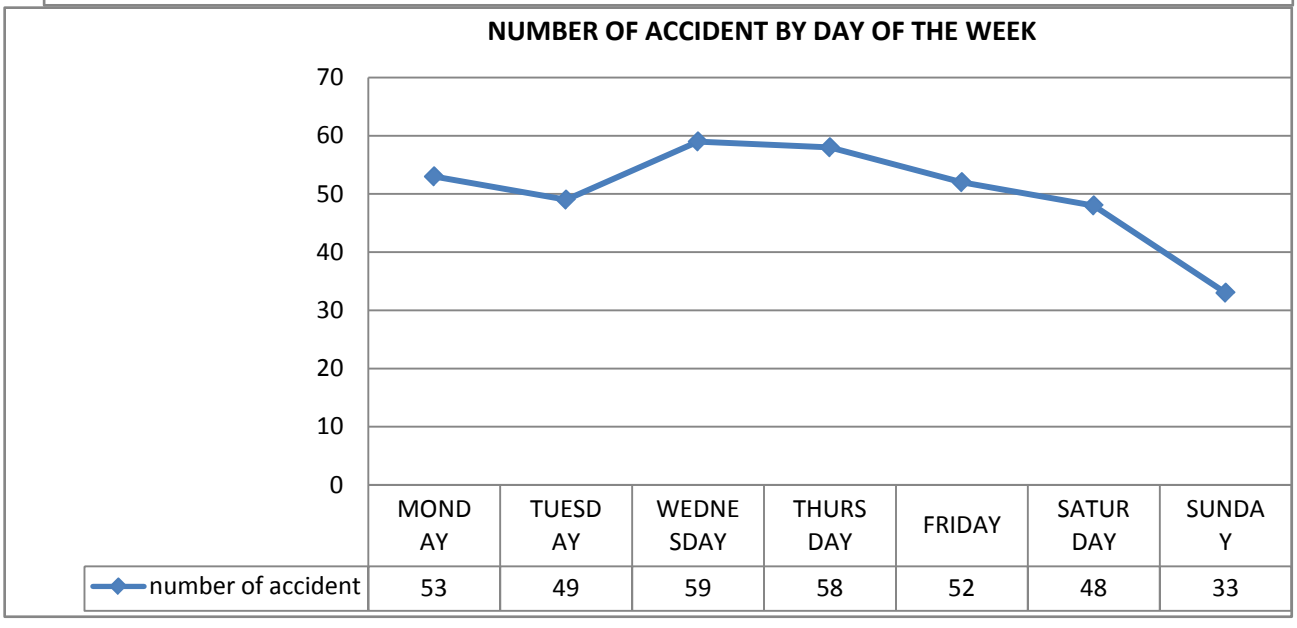
Test Statistics

	Mode of transport
Chi-Square	3090.812
df	13
Asymp. Sig.	.000

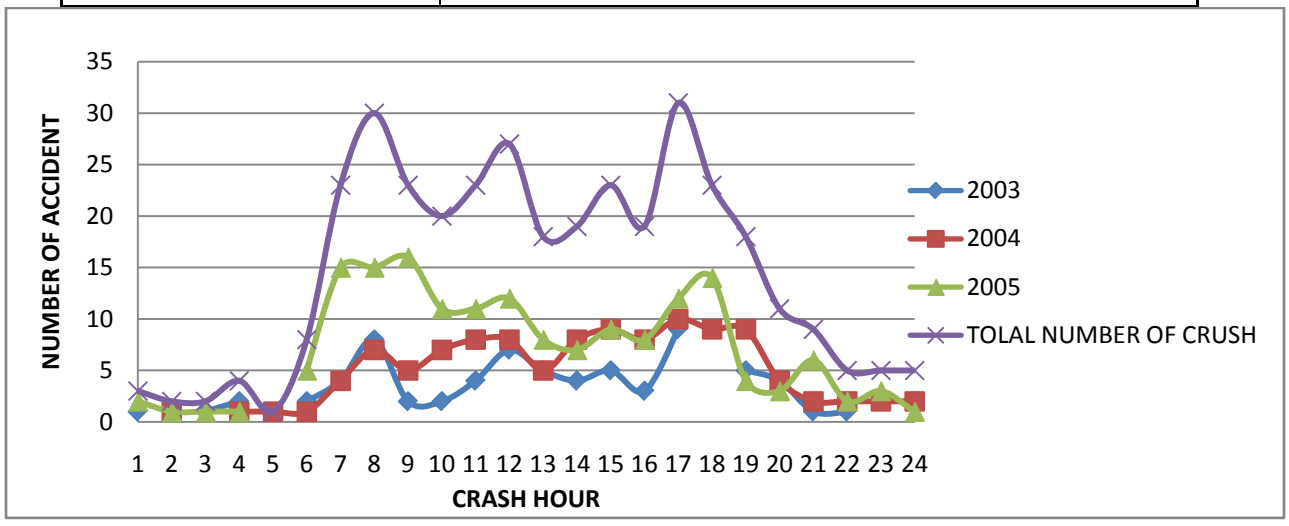
Table B-61 Saris Abo roundabout accident by, Year, Day of the week, Crash hour, and Collisions Type

Saris Abo roundabout				
DAY OF THE WEEK	NUMBER OF ACCIDENT 2003-2005 BY DAY OF THE WEEK			
	2003	2004	2005	total
MONDAY	11	19	23	53
TUESDAY	6	14	29	49
WEDNESDAY	11	15	33	59
THURSDAY	12	19	27	58
FRIDAY	11	18	23	52
SATURDAY	10	17	21	48
SUNDAY	11	11	11	33
TOTAL	72	113	167	352





CRASH HOUR	TOTAL NUMBER OF CRUSH	SARIS ABO ROUNDABOUT		
		2003	2004	2005
0100-0200	3	1		2
0200-0300	2		1	1
0300-0400	2	1		1
0400-0500	4	2	1	1
0500-0600	1		1	
0600-0700	8	2	1	5
0700-0800	23	4	4	15
0800-0900	30	8	7	15
0900-1000	23	2	5	16
1000-1100	20	2	7	11
1100-1200	23	4	8	11
1200-1300	27	7	8	12
1300-1400	18	5	5	8
1400-1500	19	4	8	7
1500-1600	23	5	9	9
1600-1700	19	3	8	8
1700-1800	31	9	10	12
1800-1900	23		9	14
1900-2000	18	5	9	4
2000-2100	11	4	4	3
2100-2200	9	1	2	6
2200-2300	5	1	2	2
2300-2400	5		2	3
2400-0100	5	2	2	1
total	352	72	113	167



Data Source: Akaki-Kaliti Sub-City Police Office; compiled by author

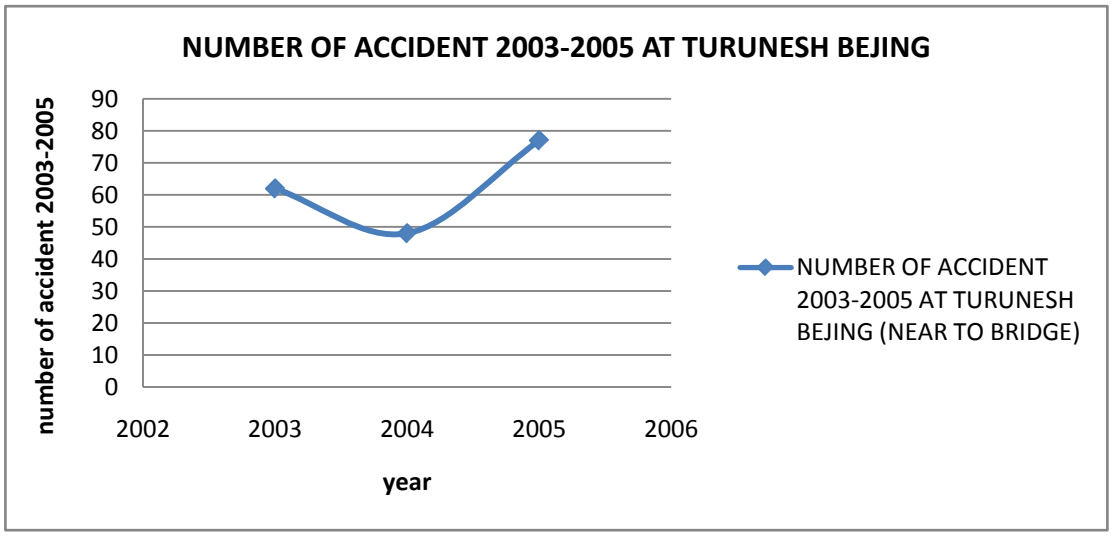
LOCATION- SARIS ABO ROUNDABOUT													
		2003				2004				2005			
No	collisions type	Fatal	Serious	Slight	Property damage	Fatal	Serious	Slight	Property damage	Fatal	Serious	Slight	Property damage
1	head on collisions				3				5				
2	rear end collisions		2	2	16		1		29		6	2	57
3	broadside collision			1	6		3		18		2	1	24
4	sideswipe collision			2	11			2	31		1	1	51
5	rollover		1		3				2				2
6	collision with pedestrians	2	12	4		3	9	3		4	15	2	
7	collision with animals												
8	fall from vehicles												
9	collision with roadside parked vehicles												
10	collision with road side objects				3				2				
11	collision with train												
12	others				3				3				
13	unknown							2					
14	total	2	15	9	45	3	13	7	90	4	24	6	134

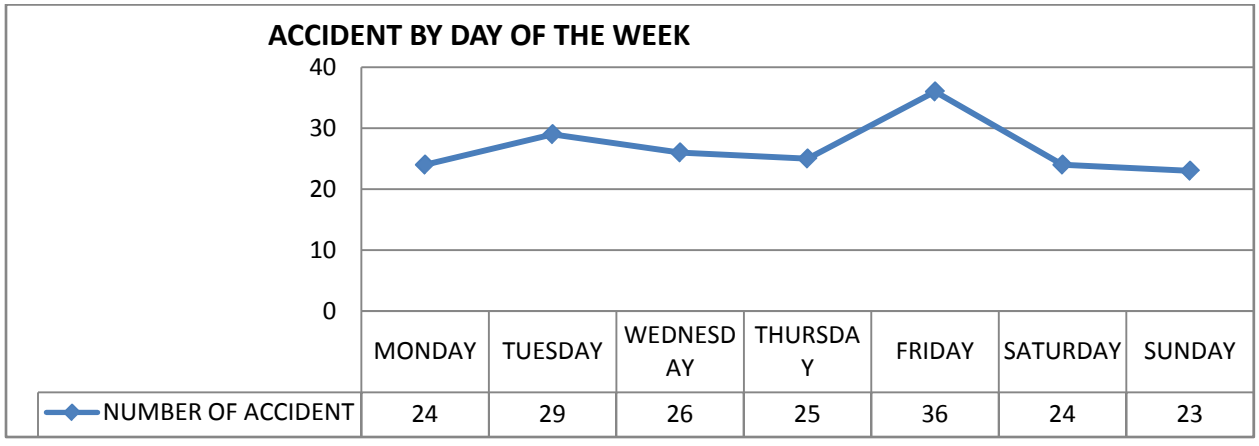
		2003-2005							
No	collisions type	Fatal	Serious	Slight	Property damage	2003	2004	2005	total
1	head on collisions	0	0	0	8	3	5	0	8
2	rear end collisions	0	9	4	102	20	30	65	115
3	broadside collision	0	5	2	48	7	21	27	55
4	sideswipe collision	0	1	5	93	13	33	53	99
5	rollover	0	1	0	7	4	2	2	8
6	collision with pedestrians	9	36	9	0	18	15	21	54
7	collision with animals	0	0	0	0	0	0	0	0
8	fall from vehicles	0	0	0	0	0	0	0	0
9	collision with roadside parked vehicles	0	0	0	0	0	0	0	0
10	collision with road side objects	0	0	0	5	3	2	0	5
11	collision with train	0	0	0	0	0	0	0	0
12	others	0	0	0	6	3	3	0	6
13	unknown	0	0	2	0	0	2	0	2
14	total	9	52	22	269	71	113	168	352

Data Source: Akaki-Kaliti Sub-City Police Office; compiled by author

Table B-62 Turunesh Beijing Hospital accident by, year, day of the week, crash hour, and collisions type

AKAKI KALITI TURUNESH BEIJING HOSPITAL(NEAR THE BRIDGE)				
DAY OF THE WEEK	NUMBER OF ACCIDENT 2003-2005 BY DAY OF THE WEEK			
	2003	2004	2005	total
MONDAY	5	6	13	24
TUESDAY	11	9	9	29
WEDNESDAY	11	5	10	26
THURSDAY	10	6	9	25
FRIDAY	13	7	16	36
SATURDAY	7	8	9	24
SUNDAY	5	7	11	23
TOTAL	62	48	77	187

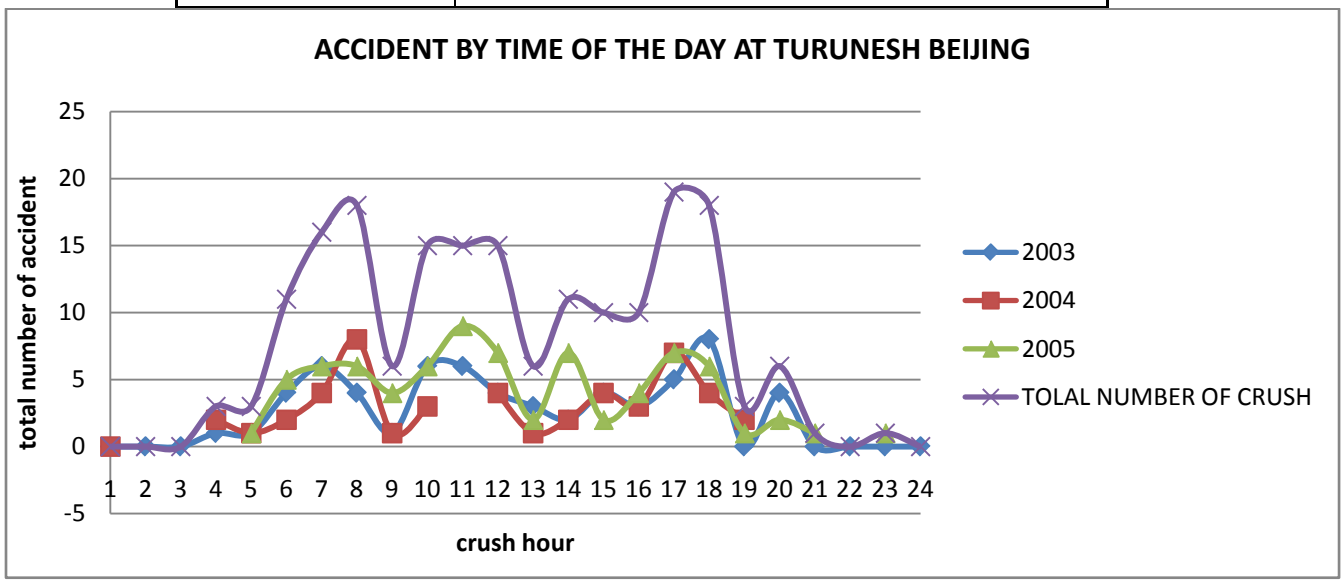




Data Source: Akaki-Kaliti sub-city Police office; compiled by author

TIME OF DAY THE ACCIDENT OCCURRED(2003-2005) AT TURUNSH BEIJING

CRUSH HOUR	TOTAL NUMBER OF CRUSH	TURUNESH BEIJING HOSPITAL(NEAR THE BRIDGE)		
		2003	2004	2005
0100-0200	0	0	0	
0200-0300	0	0		
0300-0400	0	0		
0400-0500	3	1	2	
0500-0600	3	1	1	1
0600-0700	11	4	2	5
0700-0800	16	6	4	6
0800-0900	18	4	8	6
0900-1000	6	1	1	4
1000-1100	15	6	3	6
1100-1200	15	6		9
1200-1300	15	4	4	7
1300-1400	6	3	1	2
1400-1500	11	2	2	7
1500-1600	10	4	4	2
1600-1700	10	3	3	4
1700-1800	19	5	7	7
1800-1900	18	8	4	6
1900-2000	3	0	2	1
2000-2100	6	4		2
2100-2200	1	0		1
2200-2300	0	0		
2300-2400	1	0		1
2400-0100	0	0		
total	187	62	48	77



Data Source: Akaki-Kaliti Sub-City Police Office; compiled by author

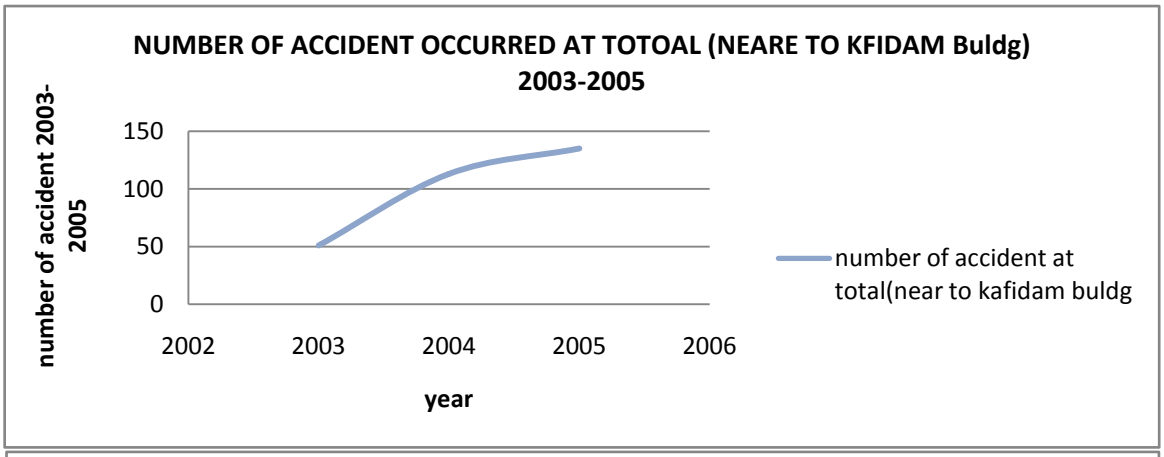
LOCATION- TIRUNESH BEIJING HOSPITAL(NEAR THE BRIDGE)													
		2003				2004				2005			
No	collisions type	Fatal	Serious	Slight	Property damage	Fatal	Serious	Slight	Property damage	Fatal	Serious	Slight	Property damage
1	head on collisions		1	2	5				1				2
2	rear end collisions		1	1	12		2	1	6		2	1	21
3	broadside collision		1		5				9			2	9
4	sideswipe collision				9			1	6		1	2	13
5	rollover				3			1					2
6	collision with pedestrians	4	8	2		4	10	4		5	12	3	
7	collision with animals												
8	fall from vehicles												
9	collision with roadside parked vehicles												
10	collision with road side objects												
11	collision with train												
12	others				8				3				1
13	unknown												1
14	total	4	11	5	42	4	12	7	25	5	15	8	49

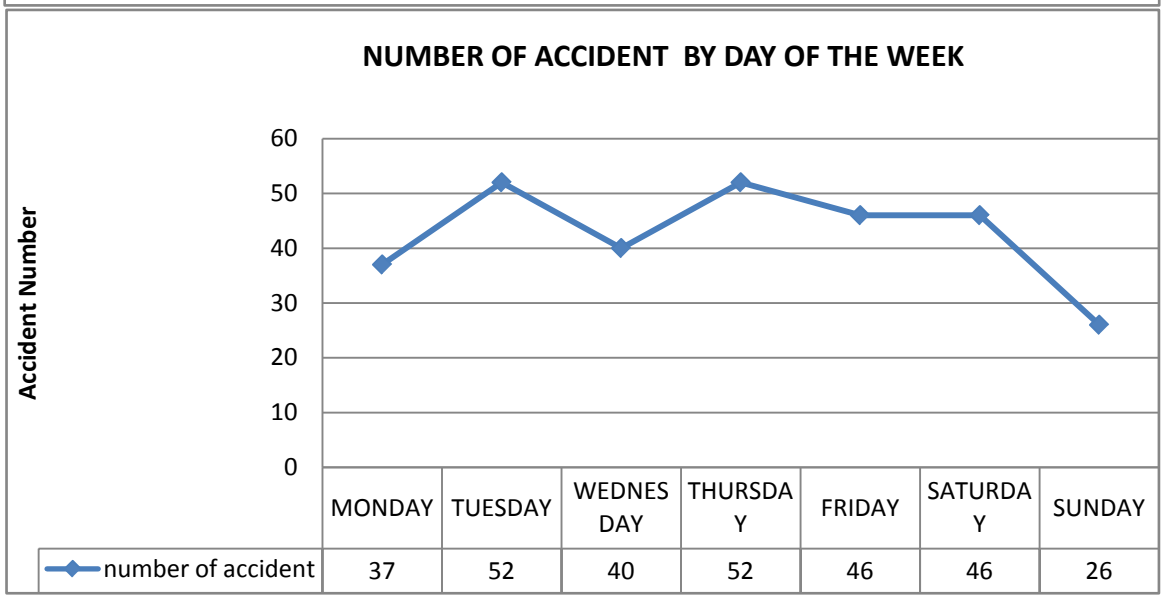
		2003-2005							
No	collisions type	Fatal	Serious	Slight	Property damage	2003	2004	2005	total
1	head on collisions	0	1	2	8	8	1	2	11
2	rear end collisions	0	5	3	39	14	9	24	47
3	broadside collision	0	1	2	23	6	9	11	26
4	sideswipe collision	0	1	3	28	9	7	16	32
5	rollover	0	0	1	5	3	1	2	6
6	collision with pedestrians	13	30	9	0	14	18	20	52
7	collision with animals	0	0	0	0	0	0	0	0
8	fall from vehicles	0	0	0	0	0	0	0	0
9	collision with roadside parked vehicles	0	0	0	0	0	0	0	0
10	collision with road side objects	0	0	0	0	0	0	0	0
11	collision with train	0	0	0	0	0	0	0	0
12	others	0	0	0	12	8	3	1	12
13	unknown	0	0	0	1	0	0	1	1
14	total	13	38	20	116	62	48	77	187

Data Source: Akaki-Kaliti Sub-City Police Office; compiled by author

Table B-63: Total (near to kafdam building) accident by, Year, Day of the week, Crash hour, and Collisions type

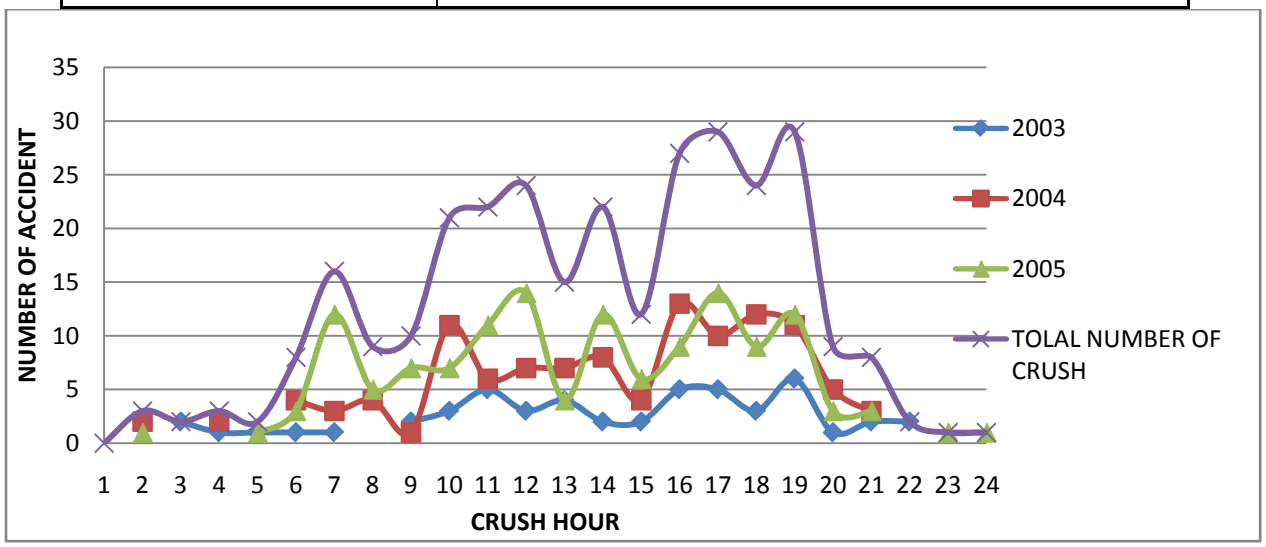
TOTAL (NEAR TO KAFDAM Building)				
DAY OF THE WEEK	NUMBER OF ACCIDENT 2003-2005 BY DAY OF THE WEEK			
	2003	2004	2005	total
MONDAY	1	15	21	37
TUESDAY	11	19	22	52
WEDNESDAY	9	14	17	40
THURSDAY	6	23	23	52
FRIDAY	10	18	18	46
SATURDAY	6	13	27	46
SUNDAY	8	11	7	26
TOTAL	51	113	135	299





TIME OF DAY THE ACCIDENT OCCURRED (2003-2005) AT TOTAL (NEAR TO KAFDAM Building.)

CRUSH HOUR	TOTAL NUMBER OF CRUSH	TOTAL (NEAR TO KAFDAM Building)		
		2003	2004	2005
0100-0200	0			
0200-0300	3		2	1
0300-0400	2	2		
0400-0500	3	1	2	
0500-0600	2	1		1
0600-0700	8	1	4	3
0700-0800	16	1	3	12
0800-0900	9		4	5
0900-1000	10	2	1	7
1000-1100	21	3	11	7
1100-1200	22	5	6	11
1200-1300	24	3	7	14
1300-1400	15	4	7	4
1400-1500	22	2	8	12
1500-1600	12	2	4	6
1600-1700	27	5	13	9
1700-1800	29	5	10	14
1800-1900	24	3	12	9
1900-2000	29	6	11	12
2000-2100	9	1	5	3
2100-2200	8	2	3	3
2200-2300	2	2		
2300-2400	1			1
2400-0100	1			1
total	299	51	113	135



Data Source: Akaki-Kaliti Sub-City Police Office; compiled by author

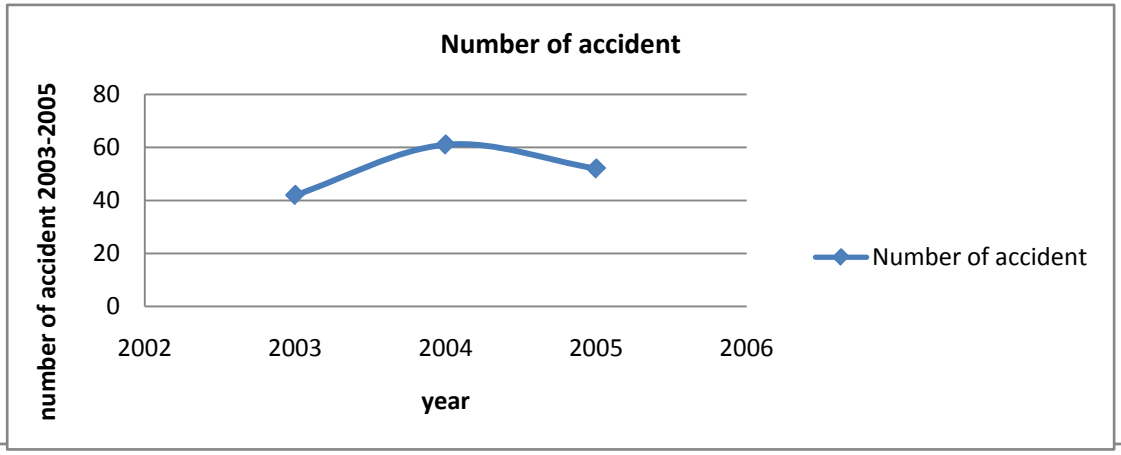
LOCATION- TOTAL(KALITI SHOA BAKERY)													
No	collisions type	2003				2004				2005			
		Fatal	Serious	Slight	Property damage	Fatal	Serious	Slight	Property damage	Fatal	Serious	Slight	Property damage
1	head on collisions				7				13				7
2	rear end collisions				15		2	2	36		1		36
3	broadside collision				5		1		15		1	1	20
4	sideswipe collision		1		10				29			1	52
5	rollover												
6	collision with pedestrians	1	5	3		2	10	2		3	3	5	
7	collision with animals												
8	fall from vehicles												
9	collision with roadside parked vehicles												1
10	collision with road side objects				1					1			
11	collision with train												3
12	others				3				1				
13	unknown												
14	total	1	6	3	41	2	13	4	94	4	5	7	119

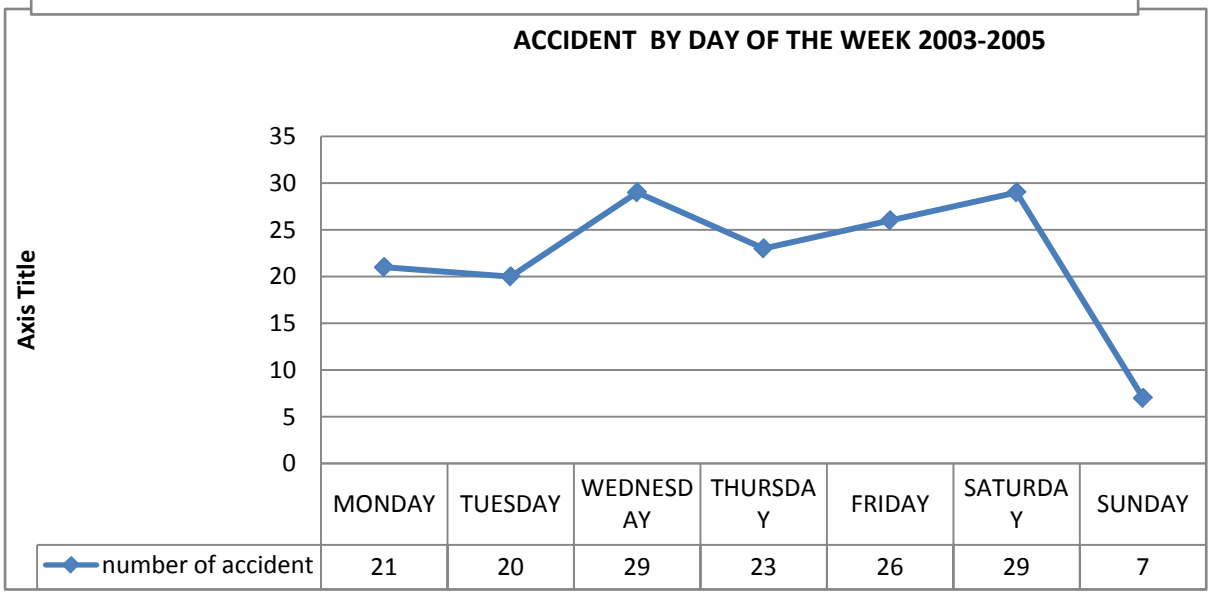
No	collisions type	2003-2005				2003	2004	2005	total
		Fatal	Serious	Slight	Property damage				
1	head on collisions	0	0	0	27	7	13	7	27
2	rear end collisions	0	3	2	87	15	40	37	92
3	broadside collision	0	2	1	40	5	16	22	43
4	sideswipe collision	0	1	1	91	11	29	53	93
5	rollover	0	0	0	0	0	0	0	0
6	collision with pedestrians	6	18	10	0	9	14	11	34
7	collision with animals	0	0	0	0	0	0	0	0
8	fall from vehicles	0	0	0	0	0	0	0	0
9	collision with roadside parked vehicles	0	0	0	1	0	0	1	1
10	collision with road side objects	1	0	0	1	1	0	1	2
11	collision with train	0	0	0	3	0	0	3	3
12	others	0	0	0	4	3	1	0	4
13	unknown	0	0	0	0	0	0	0	0
14	total	7							

Data Source: Akaki-Kaliti Sub-City Police Office; compiled by author

Table B-64 At Kaliti Driving Testing Center accident by, Year, Day of the week, Crash hour, and Collisions Type

Location Kaliti Driving Testing Center				
DAY OF THE WEEK	NUMBER OF ACCIDENT 2003-2005 BY DAY OF THE WEEK			
	2003	2004	2005	total
MONDAY	8	7	6	21
TUESDAY	5	8	7	20
WEDNESDAY	9	12	8	29
THURSDAY	4	9	10	23
FRIDAY	8	9	9	26
SATURDAY	6	13	10	29
SUNDAY	2	3	2	7
TOTAL	42	61	52	155

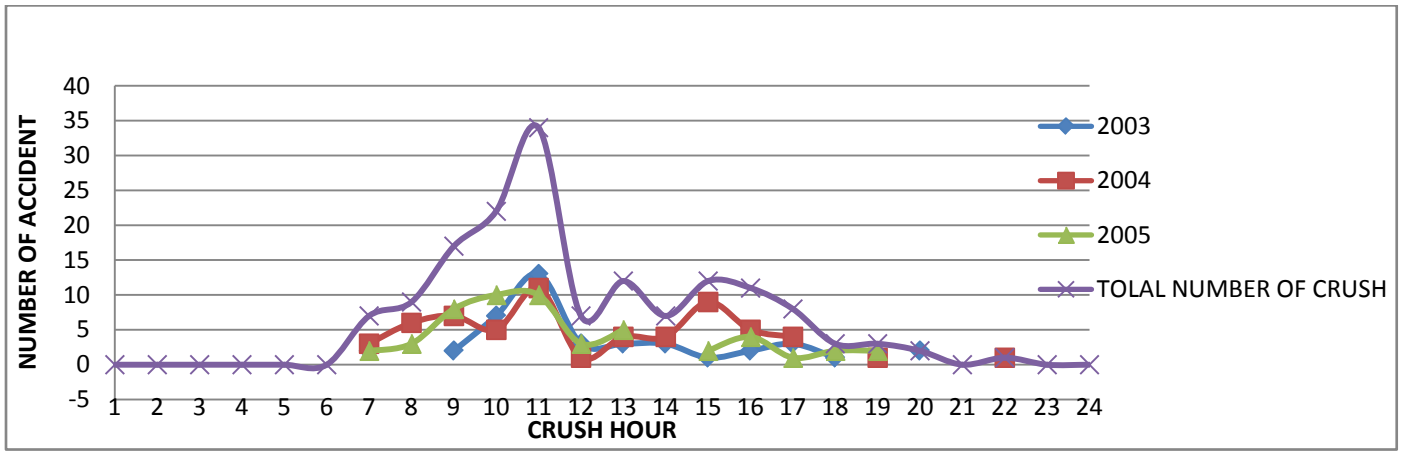




Data Source: Akaki-Kaliti Sub-City Police Office; compiled by author

TIME OF DAY THE ACCIDENT OCCURRED(2003-2005) AT TESTING CENTER

CRUSH HOUR	TOTAL NUMBER OF CRUSH	TESTING CENTER		
		2003	2004	2005
0100-0200	0			
0200-0300	0			
0300-0400	0			
0400-0500	0			
0500-0600	0			
0600-0700	0			
0700-0800	7	2	3	2
0800-0900	9		6	3
0900-1000	17	2	7	8
1000-1100	22	7	5	10
1100-1200	34	13	11	10
1200-1300	7	3	1	3
1300-1400	12	3	4	5
1400-1500	7	3	4	
1500-1600	12	1	9	2
1600-1700	11	2	5	4
1700-1800	8	3	4	1
1800-1900	3	1		2
1900-2000	3		1	2
2000-2100	2	2		
2100-2200	0			
2200-2300	1		1	
2300-2400	0			
2400-0100	0			
total	155	42	61	52



Data Source: Akaki-Kaliti Sub-City Police Office; compiled by author

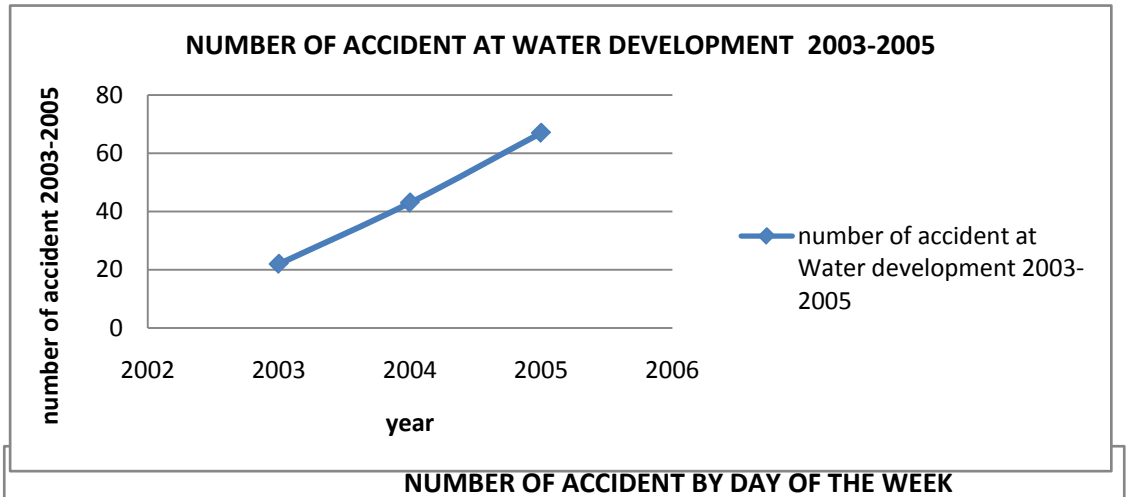
LOCATION- KALITI DRIVING TESTING CENTER													
No	Collisions type	2003				2004				2005			
		Fatal	Serious	Slight	Property damage	Fatal	Serious	Slight	Property damage	Fatal	Serious	Slight	Property damage
1	head on collisions												
2	rear end collisions				10			1	9				21
3	broadside collision				5				8				4
4	sideswipe collision				23		1	1	32		1		23
5	rollover												3
6	collision with pedestrians	1	1	1			1						
7	collision with animals												
8	fall from vehicles												
9	collision with roadside parked vehicles												
10	collision with road side objects				1				8				
11	collision with train												
12	others												
13	unknown												
14	total	1	1	1	39		2	2	57		1		51

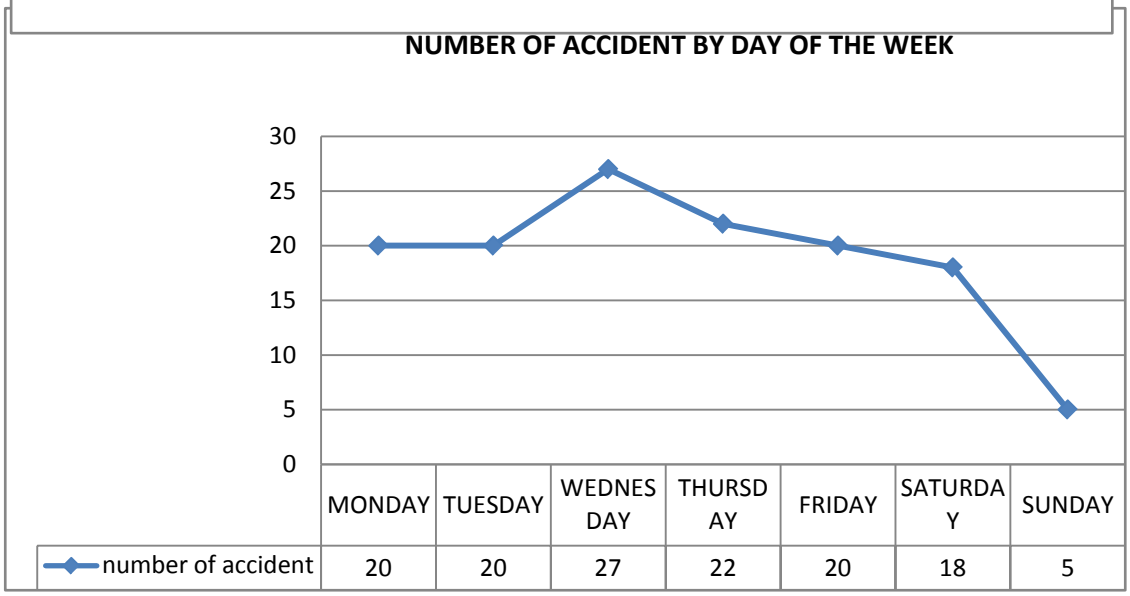
No	Collisions type	2003-2005				2003	2004	2005	total
		Fatal	Serious	Slight	Property damage				
1	head on collisions	0	0	0	0	0	0	0	0
2	rear end collisions	0	0	1	40	10	10	21	41
3	broadside collision	0	0	0	17	5	8	4	17
4	sideswipe collision	0	2	1	78	23	34	24	81
5	rollover	0	0	0	3	0	0	3	3
6	collision with pedestrians	1	2	1	0	3	1	0	4
7	collision with animals	0	0	0	0	0	0	0	0
8	fall from vehicles	0	0	0	0	0	0	0	0
9	collision with roadside parked vehicles	0	0	0	0	0	0	0	0
10	collision with road side objects	0	0	0	9	1	8	0	9
11	collision with train	0	0	0	0	0	0	0	0
12	others	0	0	0	0	0	0	0	0
13	unknown	0	0	0	0	0	0	0	0
14	total	1	4	3	147	42	61	52	155

Data Source: Akaki-Kaliti Sub-City Police Office; compiled by author

Table B-65 At Water Development accident by, Year, Day of the week, Crash hour, and Collisions type

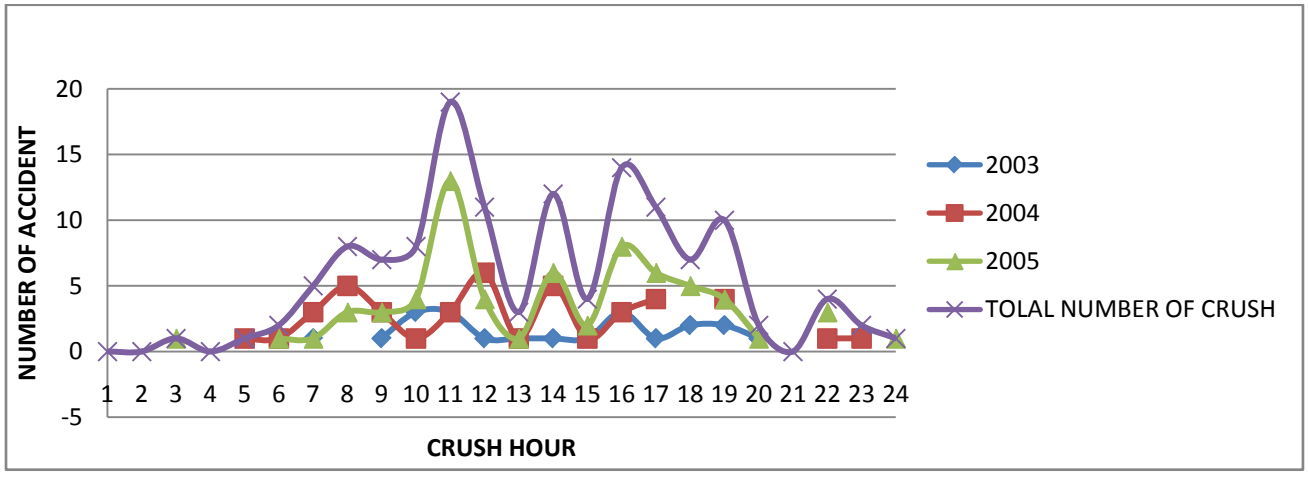
LOCATION - WATER DEVELOPMENT				
DAY OF THE WEEK	NUMBER OF ACCIDENT 2003-2005 BY DAY OF THE WEEK			
	2003	2004	2005	total
MONDAY	4	6	10	20
TUESDAY	3	5	12	20
WEDNESDAY	3	11	13	27
THURSDAY	5	6	11	22
FRIDAY	3	8	9	20
SATURDAY	2	7	9	18
SUNDAY	2		3	5
TOTAL	22	43	67	132





TIME OF DAY THE ACCIDENT OCCURRED (2003-2005) AT WATER DEVELOPMENT

CRUSH HOUR	TOLAL NUMBER OF CRUSH	WATER DEVELOPMENT		
		2003	2004	2005
0100-0200	0			
0200-0300	0			
0300-0400	1			1
0400-0500	0			
0500-0600	1		1	
0600-0700	2		1	1
0700-0800	5	1	3	1
0800-0900	8		5	3
0900-1000	7	1	3	3
1000-1100	8	3	1	4
1100-1200	19	3	3	13
1200-1300	11	1	6	4
1300-1400	3	1	1	1
1400-1500	12	1	5	6
1500-1600	4	1	1	2
1600-1700	14	3	3	8
1700-1800	11	1	4	6
1800-1900	7	2		5
1900-2000	10	2	4	4
2000-2100	2	1		1
2100-2200	0			
2200-2300	4		1	3
2300-2400	2	1	1	
2400-0100	1			1
total	132	22	43	67



Data Source: Akaki-Kaliti Sub-City Police Office; compiled by author

At Water Development

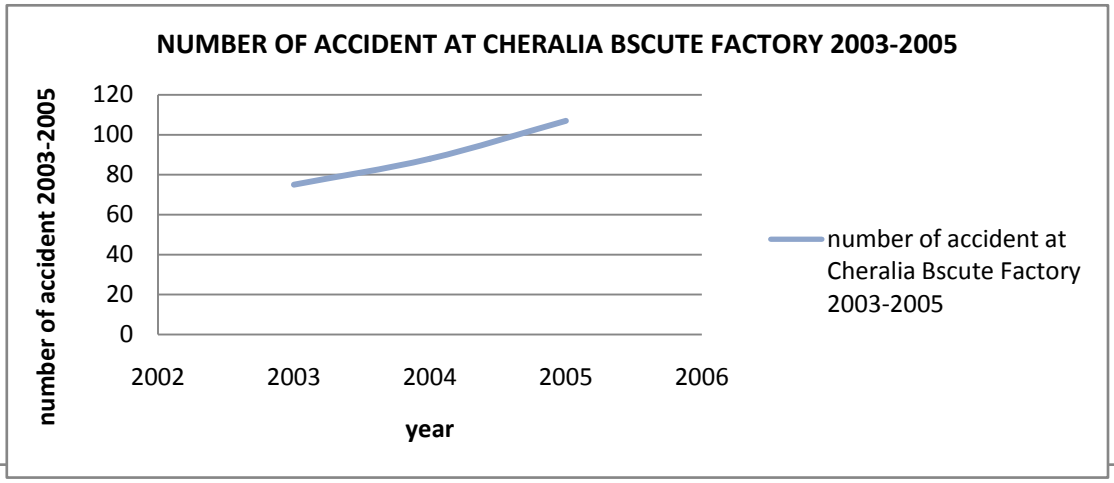
No	collisions type	2003				2004				2005			
		Fatal	Serious	Slight	Property damage	Fatal	Serious	Slight	Property damage	Fatal	Serious	Slight	Property damage
1	head on collisions				2				3				
2	rear end collisions						2		14				20
3	broadside collision				6				7				10
4	sideswipe collision			1	10				10				29
5	rollover								1				1
6	collision with pedestrians	1		1		1	2	3		2	3	2	
7	collision with animals												
8	fall from vehicles												
9	collision with roadside parked vehicles												
10	collision with road side objects												
11	collision with train												
12	others			1									
13	unknown												
14	total	1		3	18	1	4	3	35	2	3	2	60

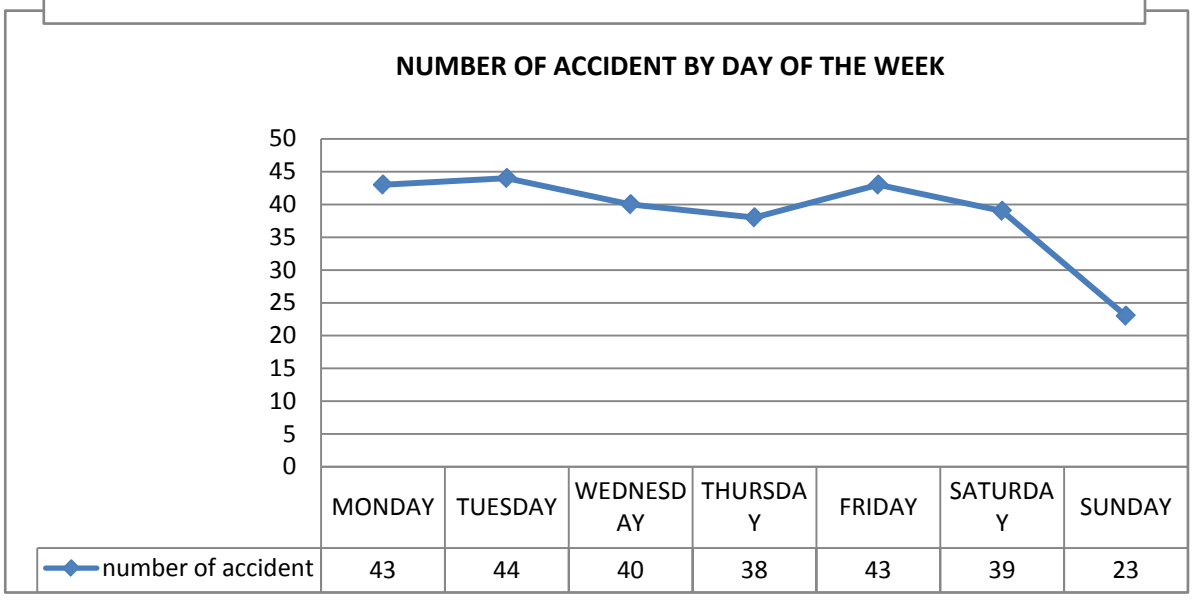
No	collisions type	2003-2005				2003	2004	2005	total
		Fatal	Serious	Slight	Property damage				
1	head on collisions	0	0	0	5	2	3	0	5
2	rear end collisions	0	2	0	34	0	16	20	36
3	broadside collision	0	0	0	23	6	7	10	23
4	sideswipe collision	0	0	1	49	11	10	29	50
5	rollover	0	0	0	2	0	1	1	2
6	collision with pedestrians	4	5	6	0	2	6	7	15
7	collision with animals	0	0	0	0	0	0	0	0
8	fall from vehicles	0	0	0	0	0	0	0	0
9	collision with roadside parked vehicles	0	0	0	0	0	0	0	0
10	collision with road side objects	0	0	0	0	0	0	0	0
11	collision with train	0	0	0	0	0	0	0	0
12	others	0	0	1	0	1	0	0	1
13	unknown	0	0	0	0	0	0	0	0
14	total	4	7	8	113	22	43	67	132

Data Source: Akaki-Kaliti Sub-City Police Office; compiled by author

Table B-66 At Cheralia Biscuit Factory accident by, Year, Day of the week, Crash hour, and Collisions type

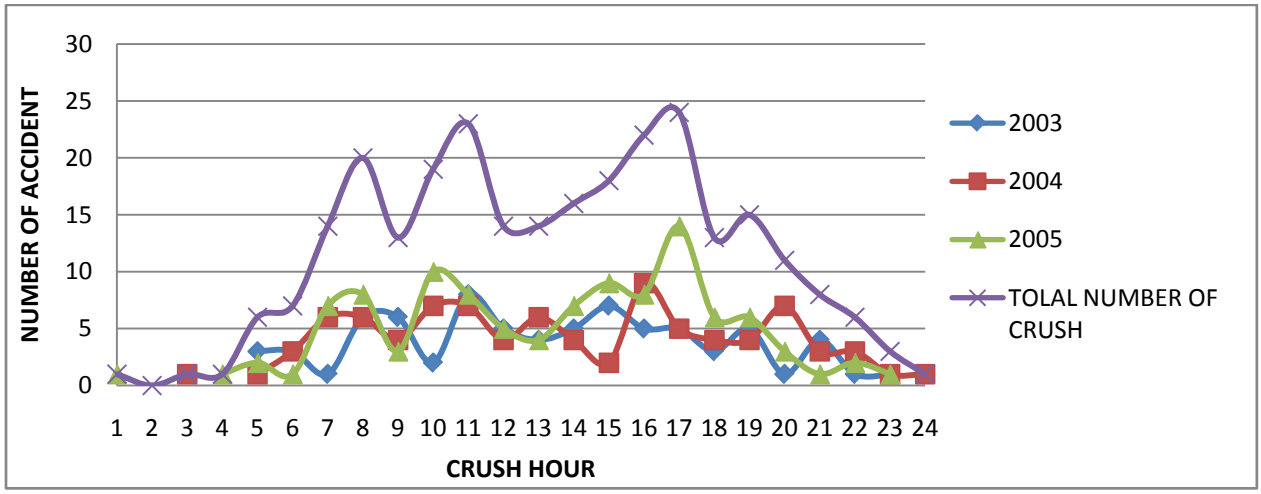
CHERALIA BISCUIT FACTORY				
DAY OF THE WEEK	NUMBER OF ACCIDENT 2003-2005 BY DAY OF THE WEEK			
	2003	2004	2005	total
MONDAY	12	16	15	43
TUESDAY	11	8	25	44
WEDNESDAY	13	12	15	40
THURSDAY	15	7	16	38
FRIDAY	6	21	16	43
SATURDAY	10	18	11	39
SUNDAY	8	6	9	23
TOTAL	75	88	107	270





TIME OF DAY THE ACCIDENT OCCURRED (2003-2005) AT CHERALIA BISCUIT FACTORY

CRUSH HOUR	TOTAL NUMBER OF CRUSH	CHERALIA BISCUIT FACTORY		
		2003	2004	2005
0100-0200	1			1
0200-0300	0			
0300-0400	1		1	
0400-0500	1			1
0500-0600	6	3	1	2
0600-0700	7	3	3	1
0700-0800	14	1	6	7
0800-0900	20	6	6	8
0900-1000	13	6	4	3
1000-1100	19	2	7	10
1100-1200	23	8	7	8
1200-1300	14	5	4	5
1300-1400	14	4	6	4
1400-1500	16	5	4	7
1500-1600	18	7	2	9
1600-1700	22	5	9	8
1700-1800	24	5	5	14
1800-1900	13	3	4	6
1900-2000	15	5	4	6
2000-2100	11	1	7	3
2100-2200	8	4	3	1
2200-2300	6	1	3	2
2300-2400	3	1	1	1
2400-0100	1		1	
total	270	75	88	107



Data Source: Akaki-Kaliti Sub-City Police Office; compiled by author

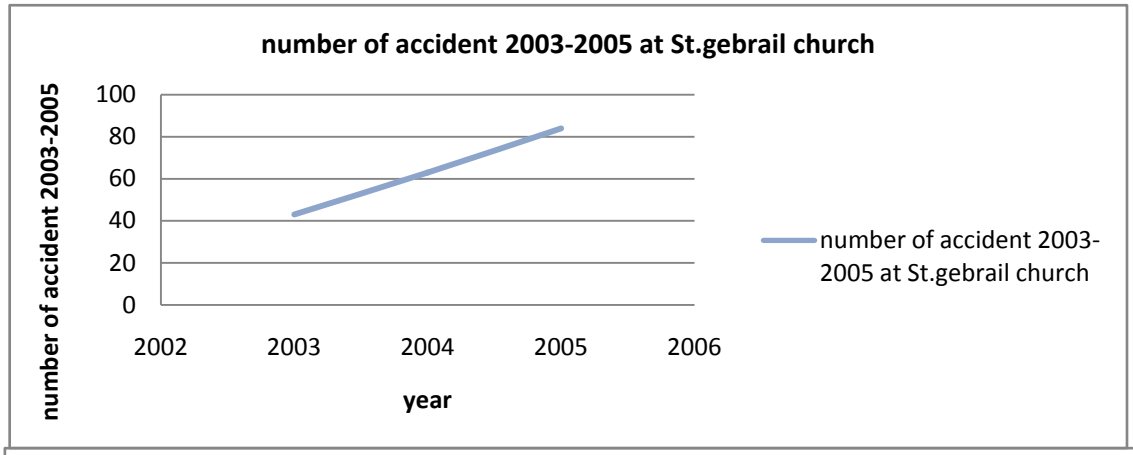
LOCATION- CHERALIA BISCUIT FACTORY													
No	collisions type	2003				2004				2005			
		Fatal	Serious	Slight	Property damage	Fatal	Serious	Slight	Property damage	Fatal	Serious	Slight	Property damage
1	head on collisions				6				6				
2	rear end collisions				21				30		2		34
3	broadside collision				1				5			1	11
4	sideswipe collision		1	2	21		1	1	16		2		39
5	rollover				1								
6	collision with pedestrians		12	8		2	16	4			11	6	
7	collision with animals												
8	fall from vehicles												
9	collision with roadside parked vehicles								1				
10	collision with road side objects								4				
11	collision with train												
12	others		1		1				1				1
13	unknown						1						
14	total		14	10	51	2	18	5	63		15	7	85

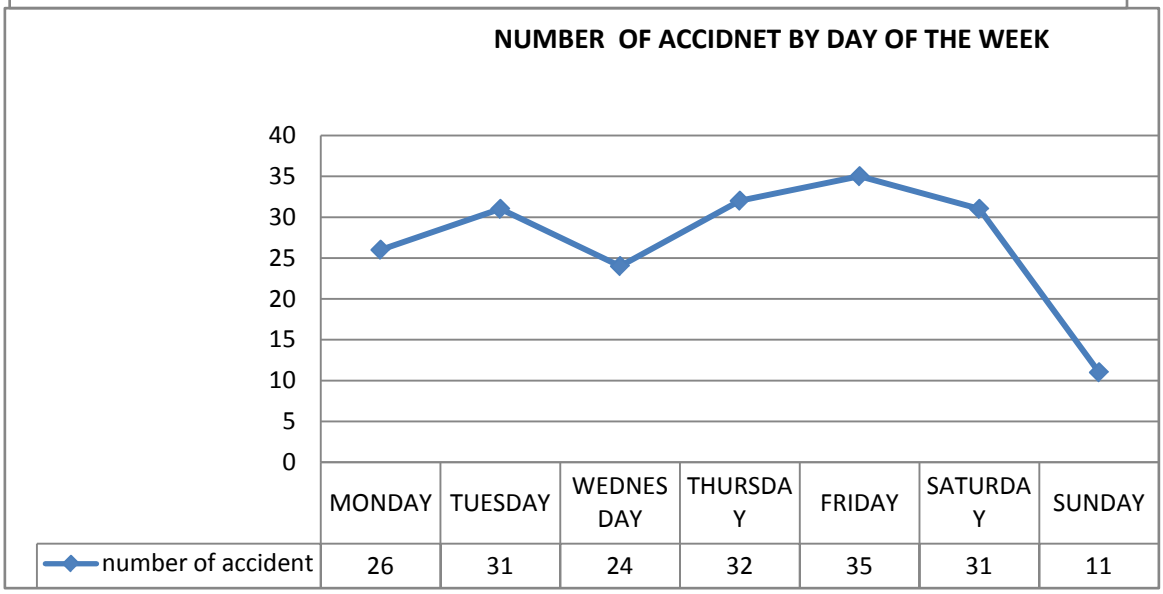
No	collisions type	2003-2005				2003	2004	2005	total
		Fatal	Serious	Slight	Property damage				
1	head on collisions	0	0	0	12	6	6	0	12
2	rear end collisions	0	2	0	85	21	30	36	87
3	broadside collision	0	0	1	17	1	5	12	18
4	sideswipe collision	0	4	3	76	24	18	41	83
5	rollover	0	0	0	1	1	0	0	1
6	collision with pedestrians	2	39	18	0	20	22	17	59
7	collision with animals	0	0	0	0	0	0	0	0
8	fall from vehicles	0	0	0	0	0	0	0	0
9	collision with roadside parked vehicles	0	0	0	1	0	1	0	1
10	collision with road side objects	0	0	0	4	0	4	0	4
11	collision with train	0	0	0	0	0	0	0	0
12	others	0	1	0	3	2	1	1	4
13	unknown	0	1	0	0	0	1	0	1
14	total	2	47	22	199	75	88	107	270

Data Source: Akaki-Kaliti Sub-City Police Office; compiled by author

Table B-67 At St. Gebrail Church accident by, Year, Day of the week, Crash hour, and Collisions type

Lcation -St. Gebrail Church				
DAY OF THE WEEK	NUMBER OF ACCIDENT 2003-2005 BY DAY OF THE WEEK			
	2003	2004	2005	total
MONDAY	9	3	14	26
TUESDAY	5	13	13	31
WEDNESDAY	4	11	9	24
THURSDAY	8	10	14	32
FRIDAY	6	12	17	35
SATURDAY	7	11	13	31
SUNDAY	4	3	4	11
TOTAL	43	63	84	190

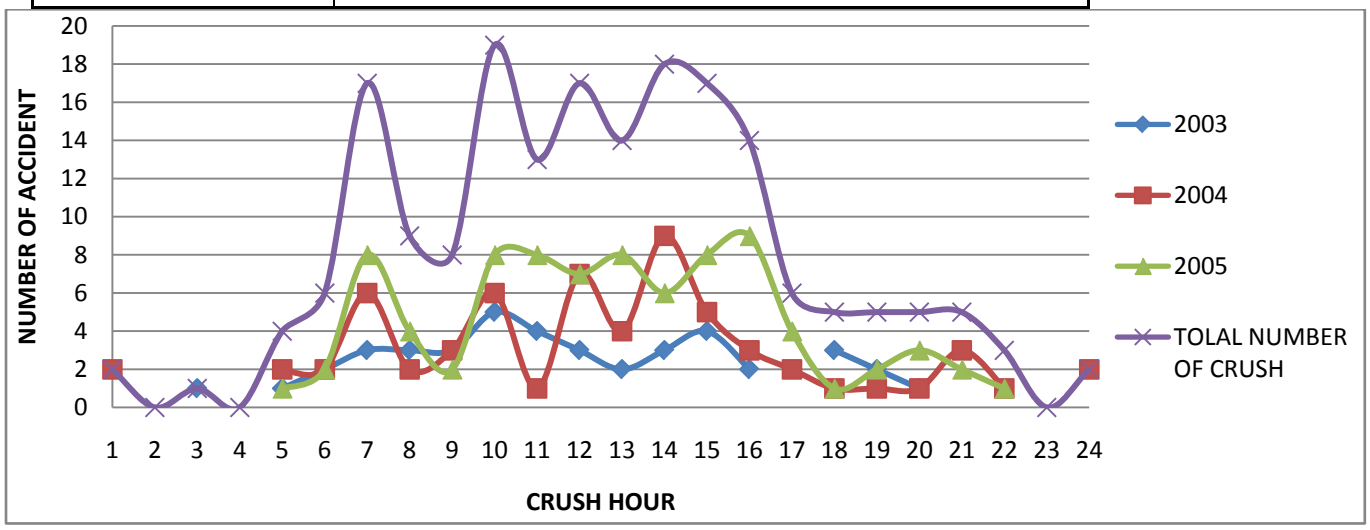




Data Source: Akaki-Kaliti Sub-City Police Office; compiled by author

TIME OF DAY THE ACCIDENT OCCURRED (2003-2005) AT St.GEBRAIL CHURCH

CRUSH HOUR	TOTAL NUMBER OF CRUSH	St.GEBRAIL CHURCH		
		2003	2004	2005
0100-0200	2		2	
0200-0300	0			
0300-0400	1	1		
0400-0500	0			
0500-0600	4	1	2	1
0600-0700	6	2	2	2
0700-0800	17	3	6	8
0800-0900	9	3	2	4
0900-1000	8	3	3	2
1000-1100	19	5	6	8
1100-1200	13	4	1	8
1200-1300	17	3	7	7
1300-1400	14	2	4	8
1400-1500	18	3	9	6
1500-1600	17	4	5	8
1600-1700	14	2	3	9
1700-1800	6		2	4
1800-1900	5	3	1	1
1900-2000	5	2	1	2
2000-2100	5	1	1	3
2100-2200	5		3	2
2200-2300	3	1	1	1
2300-2400	0			
2400-0100	2		2	
total	190	43	63	84



Data Source: Akaki-Kaliti Sub-City Police Office; compiled by author

LOCATION- KALITI St.GEBREAIL CHURCH													
		2003				2004				2005			
No	collisions type	Fatal	Serious	Slight	Property damage	Fatal	Serious	Slight	Property damage	Fatal	Serious	Slight	Property damage
1	head on collisions				3				1				
2	rear end collisions				16				25				27
3	broadside collision				3				6				13
4	sideswipe collision			1	10				20				33
5	rollover				2							1	1
6	collision with pedestrians	1	3	4		5	4	1			5	2	
7	collision with animals												
8	fall from vehicles												
9	collision with roadside parked vehicles												
10	collision with road side objects												
11	collision with train												
12	others								1				1
13	unknown												
14	total	1	3	5	34	5	4	1	53		5	3	75

No	collisions type	2003-2005				2003	2004	2005	total
		Fatal	Serious	Slight	Property damage				
1	head on collisions	0	0	0	4	3	1	0	4
2	rear end collisions	0	0	0	68	16	25	27	68
3	broadside collision	0	0	0	22	3	6	13	22
4	sideswipe collision	0	0	1	63	11	20	33	64
5	rollover	0	0	1	3	2	0	2	4
6	collision with pedestrians	6	12	7	0	8	10	7	25
7	collision with animals	0	0	0	0	0	0	0	0
8	fall from vehicles	0	0	0	0	0	0	0	0
9	collision with roadside parked vehicles	0	0	0	0	0	0	0	0
10	collision with road side objects	0	0	0	0	0	0	0	0
11	collision with train	0	0	0	0	0	0	0	0
12	others	0	0	0	2	0	1	1	2
13	unknown	0	0	0	0	0	0	0	0
14	total	6	12	9					

Data Source: Akaki-Kaliti Sub-City Police Office; compiled by author

Appendix 3: Traffic count and accident form sheets

Table C-68: Traffic count and accident form sheets

To _____
To _____

make total in the hours box during traffic flow

Road name_____
Km _____
Date _____

Vehicle type	12-1 hrs	1-2 hrs	2-3 hrs	3-4 hrs	4-5 hrs	5-6 hrs	6-7 hrs	7-8 hrs	8-9 hrs	9-10 hrs	10-11 hrs	11-12 hrs	12-13 hrs	13-14 hrs	14-15 hrs	15-16 hrs	TOTAL
→ cars																	
← cars																	
→ larger car																	
← larger car																	
→ small bus																	
← small bus																	
→ larger bus																	
← larger bus																	
→ small truck																	
← small truck																	

→																
← medium truck																
→																
← heavy truck																
→																
← tractor trailer																
→																
← motor bike																
→																
← total																

Accident							Driver					Vehicle				
No	Severity Type	Crash hour	Day/ Night	Day of the week	Date	Year	Gender	Age	Education	Relation with Vehicle	Experience	Type	Code	Plate code	Ownership	Service year

Accident of Location				Road					Lighting conditions	Weather condition	Defendant
Sub-City	Keblea	Location name	Land use	Type	Geometry	Intersection type	Pavement Type	Road condition			Vehicle maneuvering condition

Type of injuries																								Crash Reason
Fatal								Serious								Slight								
Driver No, age		Passenger No , age ,work			Pedestrian No , age ,work			Driver No ,age		Passenger No ,age, work		Pedestrian No ,age, work				Driver No ,age		Passenger No ,age ,work			Pedestrian No, age, work			

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